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Some Features of the Design of Reinforced Concrete Buildings.

The friends of reinforced concrete for building construction have made no mistake in advocating its merits, but unfortunately its use has many times been of such a character as to prove that they need to be as much on the alert against indifferent design and worse material as in advocacy of its remarkable excellence when properly designed and put in place. Indeed, concrete-steel construction is passing through a stage of development not so very different from that through which iron and steel construction passed in its earlier stages, but much more rapidly. In the latter field of engineering work efforts were at first concentrated on suitably designing the sections of main members, with little serious attention paid to details, and the same general observation may be applied without error to a considerable portion of the present practice of concrete-steel construction. The proper design of concrete-steel compression members, however, has been a matter much less simple in character than that of the corresponding steel members, or at any rate complicating practices have frequently been followed.

A suitable combination of concrete and steel to secure a well-balanced concurrent action between the two materials has long been well understood whether the combined material be used in tension or compression. The concrete-steel beam has been studied and experimented upon until practically every essential feature of its action is at least sufficiently clear to make its design approximately satisfactory. The neglect of the tensile resistance of the concrete is closely in line with this observation as well as the general omission of steel in the compression portion of the beam. It is only when a careful and intelligent scrutiny of the connection of the details at the ends of the beams, where they rest upon other beams or where they are joined to columns, has been made that the undeveloped character of a large part of the present concrete-steel practice stands out in most unsatisfactory definition. In the best practice the end shear is usually well provided for, although it is a question how far it is wise to depend upon the shearing resistance of the concrete. While experimental investigation of the resistance of concrete to shearing force has not yet been fully carried out, enough has been done to show that when the concrete is actually continuous and in good condition its capacity to resist shear is considerable. Possibly that capacity is enough to justify a safe load of 50 lb. or more per square inch, but anyone familiar with the manufacture and placing of concrete and its subsequent condition after long periods of service cannot fail to be a little disconcerted by the fine cracks which are likely to appear in such places as the ends of beams and where a condition of more or less fixedness is likely to militate against if not destroy complete continuity and so depreciate resistance to end shears. Inasmuch as the latter are the greatest in the entire beam and must be resisted at points where internal stresses in the concrete are liable seriously to injure its continuity, the dependence upon concrete for shearing capacity at such sections is questionable. Obviously, the same general observations hold where the ends of beams or girders rest upon or are built into columns. Indeed, the supporting sections of beams on each other or beams on columns are the crucial centers, so to speak, of concrete-steel construction.

The proper design of these supporting sections where shearing loads attain their maximum needs most careful and intelligent study at the present time. It is not at all a difficult matter to design such sections with ample capacity to discharge their most severe duties, but it is a serious question whether main dependence should be placed upon the concrete. It is without doubt the best procedure to dispose reinforcing metal at such points so as to enable it to carry the greater part of the shear. Under such circumstances there would be no doubt whatever of the capacity of the detail to sustain with absolute safety and certainty any load that could come upon it. While it perhaps would be a little rash, or at least unnecessary at this time, to state that the shearing capacity of the concrete should be ignored just as its tensile capacity is generally neglected, yet it would not be surprising if in the best design that position should be taken. Such features of construction would certainly secure a building safely against some of the disrupting forces which might otherwise produce dangerous consequences.

Again, the design of concrete-steel compression members, especially for high buildings, has not yet been brought to a satisfactory condition. The practice of reinforcing steel columns by a group or groups of longitudinal rods, incapable in themselves of holding compression loads of sensible amount, is open to serious criticism. No one would think for a moment of using such a combination without strong banding of the steel to hold the duplex mass together. The tendency of longitudinal loading upon such rods is to cause them to buckle and split the column. Although the banding is expected to prevent this result and does prevent it, yet the unsatisfactory combined action of the two materials is a source of weakness to the column. It is not the best of engineering design so to arrange the component parts of a member that the two tend to separate in a destructive way, even though that tendency be more or less counteracted by such a device as the banding of a reinforced column. A few simple computations with any given column design will show that the stretching of the bands within their elastic limit will be sufficient to give this disrupting tendency some play. It is not to be assumed that the banded columns properly designed may not be safe, but there is doubt whether the safety factors relied upon are absolutely attained even in the best design; and it is certain that from a purely engineering point of view the combination is not altogether satisfactory. There seems to be no reason why the steel reinforcement should not be put into the column in such a manner as to give it a high compressive resistance in itself, so that instead of tending to disrupt the concrete of the column it will act more strongly even than banding in holding the concrete together, so as to take its load in the most advantageous condition. This simply means that the steel reinforcement is a column by itself supplemented by the concrete. It is advisable that such a steel column should be open so that the concrete within it and surrounding it would be continuous, although that condition is not absolutely necessary. Both materials in such a column would act in perfect harmony so far as their elastic properties are concerned and would be so circumstanced in reference to each other as to be mutually supporting, thus securing the highest capacity of resistance for each. There is no reason whatever why a building with columns of such a character and with such details between beams and girders and between those members and columns should not be carried to any desired height.

The Theory and Practice of Trade Catalogue Production.

An examination of about a peck of trade catalogues that accumulated during the last month was a most interesting duty recently. There were many picture postals and one ponderous de luxe tome, evidently a joy to the manufacturer and certainly a joke to the printer, who deserves arrest for perpetrating it. Taken individually, at intervals, like a physician's prescription, they would have been as inoperative as most medicines, but absorbed in a gulp they produced a decided dizzy turn. The composite impression was one indicating that the people distributing them felt the need of catalogues, the manager sketched in the outline, the heads of departments wasted a few precious minutes in contributing some notes, a salesman who was sick in bed and had never heard of the fate of Ananias drew on his fevered imagination for all the good things that could be said for his line and the bad things that could be said against the other fellow's, the stenographer ran off the mess while waiting for her steady to call for her, and the office boy attended to the publishing details. The intention was all right but the impression conveyed was that of a nightmare rather than a dream.

A trade catalogue is one of the best selling devices known, when properly prepared and produced, but no amount of expensive illustrations, coated paper and multi-colored printing will make it worth much if the text and its arrangement are sloppy. The trade catalogue that contains claims so exaggerated that a salesman would be discharged for making them is worse than worthless, yet some of them are of this character. The readers of a journal like The Engineering Record are men of education, who feel that their intelligence is insulted when one of these mendacious misfits is sent to them in response to a request for information. When they ask for something substantial they don't mean a gold brick.

Some of the publications examined were good from beginning to end. The story was clean cut, the pictures meant something and the arguments were reasonable and either convincing or so stated that a man holding an opposite opinion was not insulted by them. Two catalogues in particular, sent out by companies which had built up their business mainly by mail and by advertising, could not be improved. Other publications were tagged out in the garish dress of a street walker and could only attract the same grade of intellect, and yet these offensive productions came in some cases from companies making supplies of enviably high reputation. It was evident in most cases that the companies were striving to produce good results, and yet the criticisms of such publications that reach this journal show that the art of catalogue making is not properly appreciated by most companies.

A company will pay a salesman a large salary to tell a possible customer about its product, yet it begrudges an office man a small part of the same sum to tell the same story in print to hundreds of prospective buyers. That is the explanation of the poor quality of the trade publication. The catalogue, the mailing list of present and prospective customers and advertisements in the trade papers, which together make up the publicity organization, are not at all appreciated by most companies. The president of a company whose catalogue was referred to above as a model publication, has learned by experience that this department is the most important in his business and gives it a large part of his attention. An important manufacturing company got into some trouble a few years ago and either had to increase its sales quickly and largely or go to the wall; it hunted up the best technical publicity specialist it could find, and by advertising and catalogue work he secured the orders so rapidly that he was offered the position of general manager of the company at a very high salary. Many more examples might be mentioned to show that catalogue making and the other associated work is not a boy's job. If it is so considered most of the money spent on it is thrown away. Just as soon as a young man engaged in such work produces results he is too often switched off to something else, instead of being rewarded and encouraged to keep on the development.

In theory the trade catalogue is a salesman. It must be forceful, yet pleasing; it must give the kind of information a customer wishes and not bother him by talking too much. He likes it better than a two-legged salesman, for it neither inflicts bad cigars on him or tries to take up his time when he is hurrying to catch a train. This theoretical perfection can only be obtained by similar practical perfection. The man who gets up the catalogue must know the product, which requires technical ability; he must be able to prepare a mailing list, which requires trade knowledge and publicity experience; he must be able to tell his story concisely, convincingly and gracefully, which requires literary ability; he must know about paper, type and presswork, which requires a knowledge of printing. All this knowledge cannot be hired at a boy's wages, and yet it must be employed if the great army of technically educated men who control the purchase of engineering supplies are to be interested by catalogues. A good trade catalogue makes a friend wherever it goes; a poor one gives the impression that the sender is a cheap skate, who does not know his own business well enough to talk about it even moderately well.

The Technical Supervision of Public Service Corporations.

One of the most serious problems of legislative bodies or public commissions which attempt to supervise the work of public service corporations relates to the formulation of regulations concerning the technical features of the business conducted by these companies. It is safe to say that such attempts will generally end in confusion and eventually in a declaration of their illegality by the courts. Any law or regulation which requires an individual or company to do something that is impossible cannot be upheld. In the litigation which such inequitable rules will produce, it is not at all unlikely that the regulations that ought to be enforced for the benefit of the public will be overthrown along with those that should never have been drafted. As a good example of such warped legislation concerning public service corporations, attention is called to the proceedings to date relating to the regulation of gas companies in New York State. During a happy period of inactivity in the careers of thieves, murderers and others furnishing the bulk of the news for the yellow papers, the latter were compelled to turn to other sources for the sensations their readers desire. Some isolated cases of mismanagement or lack of tact on the part of a few gas companies led to attacks in these journals on the whole industry. The many well-managed companies giving good service were made to suffer for the mistakes of a very few, and the legislature appointed a commission to investigate the subject.

This committee probably thought it was conducting a thorough investigation. It held many hearings, at some of which testimony was given that was strictly accurate and calculated to be of value, while at others the testimony was misleading and inaccurate, owing either to the ignorance of the witnesses or their desire to bolster up the case of their clients by statements that destroyed what little reputation they had for technical knowledge and veracity. As a result of the confusion produced in the minds of the members of the committee, it recommended legislation requiring a gas company to distribute its product under conditions that made it necessary either to deprive the consumer of satisfactory service or be subject to a fine of $1,000 about as often as the authorities chose to make an investigation. A more delicious opportunity for private graft by blackmailing the companies could not be devised.

As a result of the committee's profound investigation, measures were passed placing the supervision and regulation of this industry under the control of a commission. The business of manufacturing and selling gas is not simple; in the last five years it has been developing at a rate that resembles the sudden growth of the electric lighting business ten years ago. Novelties are being brought out every month which affect its technical departments, and the conduct of its business affairs is being revolutionized. Under such conditions it would be natural to assume that the members of the commission would be selected so that the body should be able to pass with certainty on the technical subjects brought before it, as well as on general questions of business and public policy. Instead of such a choice, three lawyers were appointed. This journal has no grounds for criticising the attainments of these commissioners, but it wishes to point out that, however capable these men may be as lawyers, they were not specially fitted for discharging part of the duties of this commission.

In making this criticism on the course of the Legislature in establishing a commission and on the personnel of that body, it must be understood that the point raised is not that a commission may not be of service to both the public and the industry it guards. The record of the Massachusetts Railroad Commission shows how efficient in both respects a body of this character may be. The defect of the New York proceedings lies in the way they were inaugurated and carried through. Started as a source of sensational copy for irresponsible newspapers and conducted in defiance of equity, the result is bound to be failure. In this case the commission undertook investigations on which to base recommendations for legislation; before its work was completed the matter was taken out of its hands by the Legislature, which passed a bill covering some of the subjects still under advisement. The Legislature paid little attention to the commission, however, and passed a bill before the commission finished the hearings on which it intended to base its recommendations for a similar bill. And if the Legislature shows such a disregard for its own creature, how much respect will be shown for it by sensible people. If it is desirable to place the gas industry under the control of a commission, the latter should be so constituted as to have the respect of the whole community, including the gas interests, for technical as well as business and legal attainments, and it should not be treated with such complete disregard as fell to the fate of the existing body.

The Increased Cost of Building.

It is common knowledge that the cost of putting up a building of any sort to-day is very much greater than it was five years ago, but the reason for this advance is not appreciated except by those directly concerned with such construction. One influence tending toward this increase in cost has been the general desire to improve the appearance and convenience of business and industrial buildings to a degree that would have been considered wasteful a decade ago, and another reason has been a tendency toward cheap ornament in dwelling houses of most types. The architects have protested against this gingerbread decoration, but the owners have insisted on it. These influences toward higher cost have been of slight weight, however, in comparison with the great advance that has been taking place in building materials and labor, an upward trend that few people appreciate at its real significance. While it would be difficult in most States to give definite figures on this subject, it is easy to do so in the case of Massachusetts. The market reports of the "Commercial Bulletin" run back many years and cover the leading lines of supplies, while the reports of the Massachusetts Bureau of Statistics furnish the figures concerning the prevailing rates of wages. The journal named has recently compiled these data in a way that renders a comparison of the building costs in the last five years an easy matter.

On account of the great use of lumber in American building operations, the course of the market for this material is particularly important. In May, 1901, the Boston price for ordinary spruce framing was $17; to-day the same material cannot be bought at $25. The 1901 price for matched spruce boards was $20, while to-day a builder who can buy them for $24 is lucky. Five years ago shingles sold for $2.80, while to-day a low price for the same grade is $3.45. Laths have gone up over 40 per cent. Spruce clapboards have risen 33 per cent., but the rise in clear pine clapboards has been slight. Southern lumber has shown a similar change in price. Heart face yellow pine was $35 in 1901 and is at least $49 now, with the trade association of the industry calling for $50.50. Oak has risen 25 to 33 per cent., according to grade, and other hardwoods are now held at high figures. Michigan uppers have risen from $62 to $88, and cypress from $34 to $46.50.

The next class of materials of influence in determining the cost of building operations is that used in masonry. Five years ago the quotations for common brick in Boston were reported in the "Commercial Bulletin" at $7.75 to $8, while to-day the price is $9.75 to $10.50. It is interesting to observe that the jump upward has taken place almost entirely within the last year, and was probably due to the demand brought about through the unusually protracted building season of 1905. Lime is now about 15 per cent. above the 1901 figure. The fluctuations in Portland cement during this five-year period in Boston have been as marked as elsewhere in the country. In May, 1901, the prevailing quotation was $1.54 in bags. It ran up considerably and then fell to $1.65 in May, 1905. Since then the market has been steadily hardening and now stands at $1.90 to $1.95 with every prospect of much higher prices and a shortage by fall.

Turning to the wages for labor the increase has been just as marked. Bricklayers were paid 47 cents an hour in 1901 and 55 cents is now the prevailing rate; for carpenters the figures are 25 and 30 cents, house painters 30 and 35 cents, plasterers 47 and 50 cents, plumbers 44 and 50 cents, gravel roofers 30 and 34 cents, slate roofers 36 and 40 cents, and sheet metal workers 33 and 37 cents. The average increase in wages in Massachusetts has been 13¾ per cent., and there has been an unquestionable falling off in the average degree of skill and productiveness of the men. These facts in conjunction with an average increase of 27½ per cent. in the cost of the materials used in buildings explains the cause of a large part of the extra expense of the work done to-day over the cost five years ago.

On the face of the figures it would seem that the advance in the price of materials has taken place more rapidly than the advance in wages and in consequence the skilled workmen have been getting less advantage from the condition of prosperity than the owners of companies furnishing materials. This is incorrect, however, for it does not take into consideration the enhanced cost of turning out materials. In the case of lumber the diminution of the supply has been operating to raise the price steadily, and in every industry there has been an increase in wages probably not unlike that in the building trades. If the wages have risen at the same rate, then the increase of 27½ per cent. for materials means an increase of something like 13¾ per cent. for the workmen producing them and a similar increase for the companies engaged in the building materials business. If in addition to the added expense for labor and materials, allowance is made for a rise in the value of real estate, it is probably safe to say that the average building costs about 40 per cent. more to-day in the Boston district than it did five years ago.

Notes and Comments.

THE FERRIS WHEEL, the pride of the Columbian Exposition and the joy of the Louisiana Purchase Exposition, has made its last turn. On May 11 a charge of dynamite was fired under one side and it crumpled up slowly into a tangled mass of steel. It was the first large wheel designed by an engineer of high standing, and the analysis of the stresses in its frame has interested many designers of steelwork, even arousing a considerable controversy at one time.

GASOLINE IN SEWERS is the latest source of danger to the metropolitan citizen. In the garage district of New York there have been a number of explosions in manholes where such things never happened before, and the only inference that can be drawn from the conditions attending these explosions is that gasoline is responsible. Nobody has any confidence in the intelligence and honesty of the average New York chauffeur. His knowledge is not sufficient to acquaint him with the danger of pouring gasoline into the drainage system of a building, while his grafting proclivities encourage him to make use of this ready method of increasing the amount of purchases made for his employer's account, and thereby his own commission. There should be rigid regulations with heavy penalties prohibiting any such use of the sewers of a city.

THE CHICAGO CITY HALL continues to be the cause of animated controversy between those who wish to build a new and palatial home for the city fathers and the executive departments, and those who think that the building can be tinkered up to last some time without any greater menace to those within it than in the past. The Engineering Record sympathizes with those who feel that the rummy old shack should be torn down, but until some engineers and architects of high professional standing assert after a careful detailed examination that the structure is unsafe, this journal will hold the opinion that the stories of its instability are largely manufactured by the advocates of a new building. Chicago needs many more policemen, costly improvements in the water system, better pavements and other things more useful to its citizens than a new city hall. If the building is unsafe it certainly ought to be replaced at once, but the reports concerning its dangerous condition look too much like the exaggerated statements of a theatrical press agent to be accepted at the face value. It is amusing to learn that one reason for tearing down the building is that a peppermint test of the plumbing system indicated many leaks; it is safe to say that such a test at any time in the last five years would hvae resulted in a similar discovery, for the condition of the plumbing has been notoriously bad.

THE SUMMER SCHOOL FOR ARTISANS, held under the direction of the College of Engineering of the University of Wisconsin, will begin its sixth session on June 25. This interesting venture in technical instruction was begun at the incentive of the late J. B. Johnson, and has rapidly progressed from the stage of a questionable experiment to a condition of assured success. Prof. Johnson was one of the first engineering professors of high standing to recognize the usefulness of correspondence instruction, and he proposed to make this summer school supplement that work. It affords an opportunity of obtaining a working knowledge of the methods of testing and the use of instruments, together with such theoretical principles as the nature of the subject and the preparation of the student may permit. The requirements for admission do not extend beyond a working knowledge of English and arithmetic, and the policy is to allow a large amount of individual work, so that the student may take advantage of all the preparation he has obtained. The entire outlay for school fees and living expenses during the six weeks' term is estimated at fifty dollars. The action of the University in placing its laboratories and some of its teaching staff at the disposal of young men unable to take a regular college course is in keeping with its long record of public-spirited usefulness, and deserves the warm commendation of all who believe that the ambitious young men in American shops should be encouraged to master the principles on which their work depends.

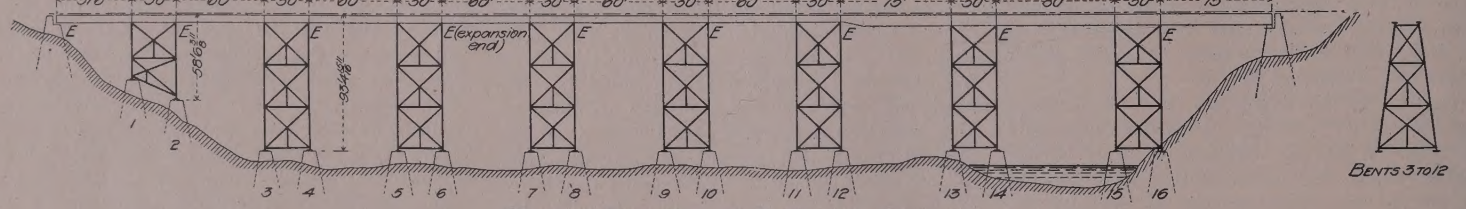
THE WATER FILTERS at Lawrence, Mass., are to be supplemented by a new filter built from the plans of Mr. Morris Knowles. The design was made in 1903, but an appropriation for construction was not made until recently. The present filter, although not the first open sand filter in the country, was very interesting as being the first to embody the information obtained by the Massachusetts State Board of Health in its investigations of water purification. It was described in this journal on Feb. 3, 1904. The new filter will be 313x103 ft. inside and have a net sand area of about three-quarters of an acre. There will be a floor of inverted groined arches 6 in. thick at the center and 15 in. thick under the 22x22-in. piers on 15-ft. centers that support the roof. The latter will consist of semi-elliptical groined arches with a clear span of 13 ft. 2 in. and a rise of 2 ft. 9 in.; they will be constructed of concrete 6 in. thick at he crown and 21 in. over the piers. The main collector will be a concrete arched drain above the general floor level, from which the terra cotta laterals will run, reducing in size from 12 in. at the main collector to 6 ft. at the outer end. The raw water will enter an inlet chamber at one corner of the filter where a regulating valve controls the amount of the supply. It then flows over weirs in the walls of the chambers into open troughs carrying it along the side walls of the filter. These troughs are provided with orifices of varying sizes, according to their position, so that the inflowing water is uniformly distributed over the sand.

A GREAT HIGHWAY through the State of Pennsylvania, from Philadelphia to Pittsburg, was strongly urged last week by Governor Pennypacker, Speaker Walton and other public officials at a gathering in the Union League Club in the former city. It is stated that the project was enthusiastically received and it is now being backed by influential newspapers. The Pennsylvania laws for aiding the construction of good roads are liberal, and it may be that under them it would be possible to provide a considerable part of the proposed road. As a general proposition, however, it can be said that the best results of State aid are secured by building stretches of road of a few miles in length in different places, where they will serve as object lessons and thus lead to the construction of other necessary roads at local expense solely. It may be that a continuous highway between the two cities would prove of sufficient use to the communities through which it passed to warrant its construction. On the other hand, the project has the general complection of the schemes of automobile associations to persuade communities to build expensive roads they do not need so as to permit the owners of motor cars to have long-distance runs over the best of highways. If it were possible to get a proportionate contribution from motorists for the construction and maintenance of these roads the projects for them would deserve attention. At present, the only way to secure the necessary funds seems to be to employ a vigilant constable and enact a slow speed law with high fines for its violation.

REPLACING THE ASHTABULA VIADUCT.

The New York, Chicago & St. Louis Railroad originally crossed the Ashtabula creek in Ohio on a single-track wrought iron viaduct 822 ft. long between abutments and 93½ ft. in maximum height, which weighed 547,000 lb. The structure was built in 1882 and comprised one 170-ft. pin-connected double intersection Whipple truss deck span seated on masonry piers, seven 60-ft. and seven 30-ft. pin-connected Fink truss spans with wooden stringers, and six 30-ft. and one 22-ft. pin-connected towers, each having four battered posts seated on individual masonry piers. The viaduct was designed to carry two 66-ton ten-wheel locomotives followed by a train load of 3,000 lb. per linear foot. For this service the members of the truss and towers were very light and the 30 and 60-ft. trusses 10 ft. apart transversely, were remarkable for their respective depths of about 10 and 28 ft. The structure was built under the direction of Mr. J. A. Latcha, chief engineer at that time.

With the increasing speed, weight and frequency of trains and the much heavier locomotives now used, it became necessary to replace most of the old bridges of this railroad with heavier ones suited not only for present requirements but for reasonable future increase. This work was commenced about 1900 and eleven of the principal viaducts from 33 to 99 ft. high and from about 600 to 1,500 ft. long, with an aggregate weight of about 7,800 tons, have already been reconstructed, an essential requirement being that no interruption of more than two hours could be permitted while maintaining the traffic of about 60 trains daily.



General Elevation of Ashtabula Viaduct.

The new structure for the Ashtabula viaduct was built in 1904 and has the same grade and alignment as the old one. It consists entirely of plate girder spans carried, except for the channel span, on the old masonry piers, and on eight new steel towers. All of the new towers have a uniform width of 30 ft. and are 60 ft. apart, except at the river crossing, which is made with one 80-ft. span flanked by two 75 ft. spans.

The structure is proportioned for two 136-ton consolidation locomotives followed by a train load of 4,000 lb. per linear foot. The unit direct working stresses were figured by the formula, $S = 7{,}500$ (minimum/maximum) and the unit alternating stresses by the formula, $S = 7{,}500$ (1 — maximum stress, lesser kind/maximum stress, greater kind).

The dead load was computed for the estimated weight of the structure plus an allowance of 450 lb. floor load per linear foot of track. The lateral system is proportioned for a moving load of 480 lb. per linear foot except for the 75 and 80-ft. spans, which are proportioned for 570 lb. The towers are proportioned for transverse stresses due to a concentrated load of 1,000 lb. at the top of each, plus 150 lb. per linear foot of the structure applied at the base of the rail and a wind pressure of 300 lb. per linear foot assumed to be applied 8½ ft. above the base of rail on the train surface. An additional horizontal pressure of 2,700 lb. was assumed to be applied at each transverse strut. The longitudinal bracing was proportioned to resist the momentum of a train suddenly stopped under the assumption that the coefficient of friction of the wheels sliding on the rails is 0.2.

All material except rivets is open hearth steel with an ultimate strength of 56,000 to 64,000 lb. All bracing not subject to static live load stresses was proportioned for working unit strains of 15,000 lb. for tension, 12,000 lb. for shear, and 24,000 lb. for bearing. Expansion rollers have a diameter to $c/300$ where c is the allowed pressure per linear inch of roller. Web plates are proportioned for a shearing strain of 6,000 lb. per square inch, and are not assumed to resist any portion of the bending stresses. The top and bottom flanges have the same gross cross-section, and web splices at the center of the span are avoided. The number of rivets in connections are increased 25 per cent. when driven in the field.

All girders have pairs of vertical web-stiffener angles at the end and are symmetrically arranged intermediately at distances not greater than the depth of the girder and wherever the unsupported distance between the flange angles exceeds fifty times the thickness of the web. The ends of the stiffeners are tightly fitted to the flange angles and they are riveted to the girder with filler plates.

Great attention was paid to making all surfaces readily accessible for cleaning and painting and to avoid pockets which would permit the collection of water. These considerations led to the adoption of Z-bar columns for the tower posts. It was at first intended to connect the tops of the tower posts by transverse girders carrying the longitudinal girders, but considerable economy was effected in the design by substituting a strut for the transverse girders and setting the main girders on the column tops.

The contract was awarded by competitive bids based on a fully detailed design issued by the engineering department. Special consideration was given to a very thorough inspection of material and manufacture. The mill reports of chemical analyses were accepted, and competent inspectors reporting to the bridge engineer were employed to make tension and bending tests and to inspect materials and workmanship at the shops. Care was taken to insure all material being carefully cleaned with wire brushes and painted when dry. All new masonry is of 1:3:8 concrete, and was built by day labor under the direction of the engineering department.

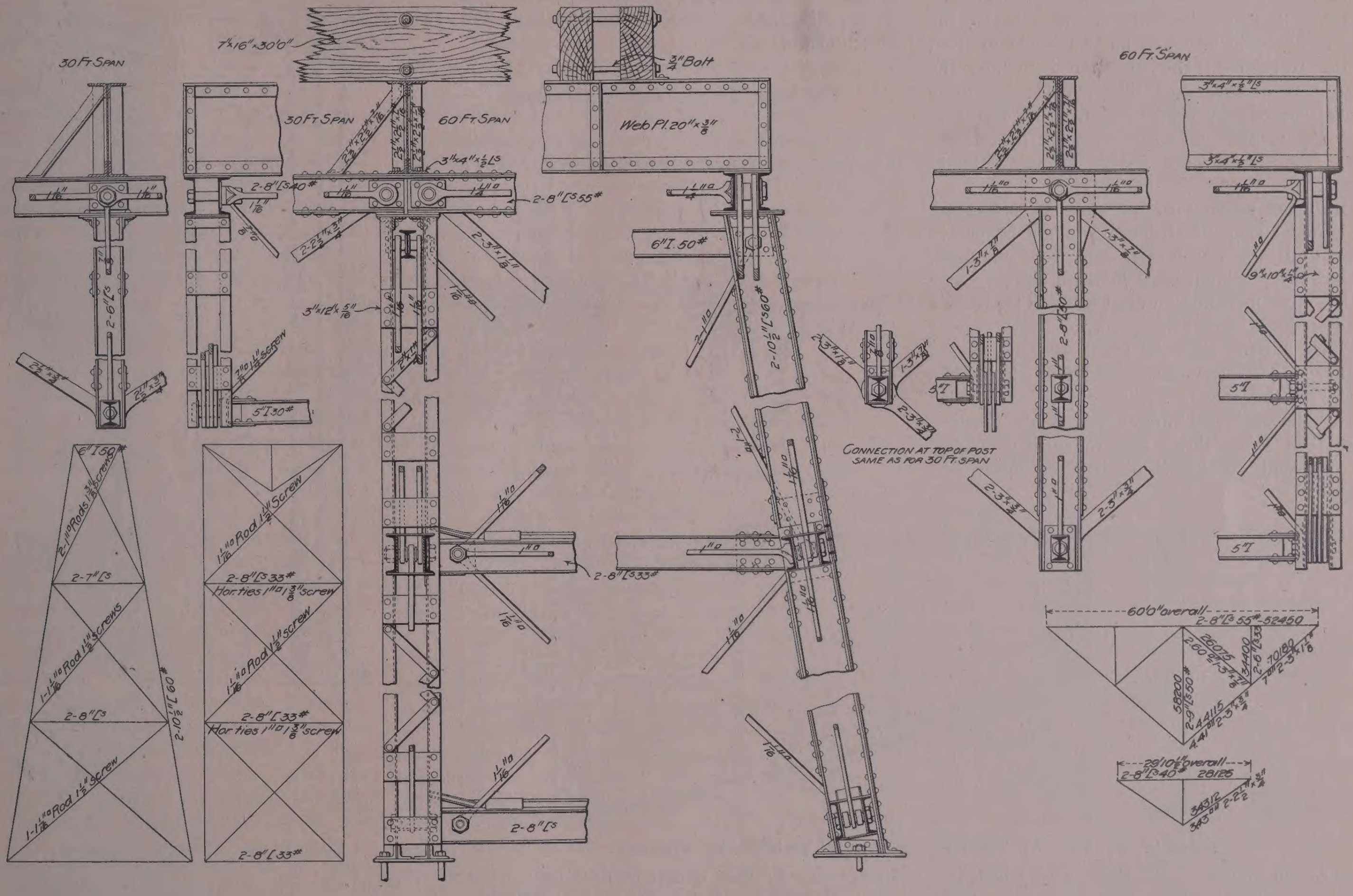
The towers are all of uniform construction as indicated by the general diagram, and all connections are riveted. They have a maximum height of about 93 ft. from the top of the masonry to the base of the rail and the posts are spaced 8 ft. apart on centers at the top and are battered 2 5/16 in. per foot, giving a maximum width of 39 ft. 9½ in. at the base of the tallest tower. All towers, except a short one at one end, are essentially duplicates and are made in three stories with the columns field-spliced in the top story only. The connections and details of the tower illustrated are typical for all. The H-shaped posts are made of four 6x7/16x3 9/16-in. Z-bars and one 8x7/16-in. web plates. Both longitudinal and transverse horizontal and diagonal members are field-riveted to the post through pairs of jaw plates shop-riveted to the webs of the Z-bars or across their flanges. The posts have 24x⅞-in. base plates and cap plates, the former being seated on ¼-in. sheet lead fillers inserted between them and the masonry, and the latter being provided with longitudinal guide strips clearing the edges of the girder bearing plates. Horizontal struts have I-shaped cross-section made of two pairs of angles latticed, and the diagonal members are made of two angles latticed.

The 75-ft. and 80-ft. girders and the 30-ft. girders between them have a depth of 8 ft. All other girders have 60-in. webs and the ends of one span of 75-ft. girders are beveled to the same depth in order to be seated with the other girders on the same tower. The girders are 8 ft. apart on centers and are braced together with zigzag top and bottom flange angles, alternate panels being divided by the usual transverse sway-brace frame made of single 3x3 and 5x3½-in. angles. The swaybracing is field-riveted to the vertical web-stiffeners of the main girders and has horizontal connection plates slotted to clear the latter and field-riveted to the girder flanges. The lateral angles are also field-riveted to the top and bottom flanges of the girders.

The 75-ft. girders are made with web plates about 15 ft. long which are ⅜ in. thick in the center of the girder and 7/16 in. thick at the ends. Their splices are uniformly made with two 12x⅜-in. cover plates and four vertical rows of rivets. Each section is divided into three panels by pairs of vertical 5x3x⅜-in. angles with fillers. The top flange is made of a pair of 6x6x⅞-in. full-length angles, one 15x½-in. full-length cover plate, one 15x½-in. 47-ft. and one 15x7/16-in. 32-ft. cover plate. The bottom flange has the same cross-section except for the difference in the length of the cover plates, the first one terminating about 8½ ft. from the deep end of the girder.

At the drop end, the lower flange of the girder is inclined upwards for a length of 15 ft., both cover plate and flange angles being continuous and bent to suit. This end of the girder is supported on a nest of six 2½-in. rollers about 21 in. long. They have special bolts with shouldered ends and slotted countersunk heads, which are tapped into each end and connect them to the side bars. A 27x13/16x16-in. shoe plate is riveted across the end of the lower flange and projects nearly 8 in. on each side, where it is stiffened by a pair of vertical diaphragms riveted to the web-stiffener angles, thus providing a more stable base than would be afforded by the width of the flange. Longitudinal guide strips are riveted to each of the outer edges of the sole plate and engage the ends of the rollers, which are not slotted since there is no center guide rib. At the fixed end the 24x13/16x16-in. sole plate is filled out about 2½ in. beyond the backs of the flange angles and is stiffened only by the vertical transverse connection plate for the end sway-frame. The plate is planed on the lower surface where it is seated on the post cap. The 30, 60, 75 and 80-ft. spans complete weigh respectively 16,100, 49,200, 74,100 and 81,700 lb. each.

The girders and braces were shipped separately and field-riveted complete in a storage yard established near one end of the bridge. Ordinary framed falsework bents were erected on rock bottom under the 170-ft. old span to carry it and the track. The remainder of the old structure was removed and all of the new structure erected without the use of falsework. As the ground under the trestle was approximately level, it was easy to lay there a standard-gauge track 27¼ ft. from the center line of the bridge on each side, just clearing the piers of the old and new towers. On these tracks there was erected a three-bent wooden striding traveler 136 ft. high, 54 ft. long and 31 ft. wide over all. It had a train clearance about 22½ ft. high, and 18 ft. wide at the bottom which enabled it to move over and outside the old and new viaducts and the trains which passed on them. It was built principally of 12x12-in. main timbers, 4x12-in. diagonals and 6x12-in. struts with one or two ¾-in. bolts at every intersection. Except for its dimensions and the tapered form of the inside clearance, the traveler resembled the ordinary tower traveler used for long-span bridge erection and was supported on six standard car axles each of 100,000 lb. capacity. The upper part of each bent consisted virtually of a wooden Howe truss carrying over the centers of each line of girders in the viaduct a pair of 8x16 in. longitudinal jigger beams, from which were supported the main tackles operated by two Lidgerwood hoisting engines located on platforms level with the track. The bents were framed and bolted together on the ground beneath the viaduct so that each bent was complete in itself before the erection of the traveler was commenced. Two sections of traveler track were built, on which were placed the sills of the traveler on the car axles. The bents were then taken apart in sections and erected on the sills to the height of the deck of the viaduct, by means of gin poles secured to the tops of the old columns. These portions of the bents were held in place by shores to the old structure and the bracing between the bents put in place.



Old Viaduct for Ashtabula Crossing.

The remainder of the traveler was then erected by gin poles placed on those portions already erected.

When the bridge material began to arrive at the site of the viaduct, the cross frames and girder laterals were put in place and the girders riveted together in the material yard in readiness for placing in the viaduct. With four exceptions the longer columns, which were all spliced, were lined up and the rivets in the splices were driven in the yard. The actual work of renewing the viaduct was commenced at the west end on July 18, 1904. On account of the slope of the ground it was necessary to use gallows frames in place of the traveler to put in the first bent and first span. A gallows frame was also used in connection with the traveler in placing the second bent and second span.

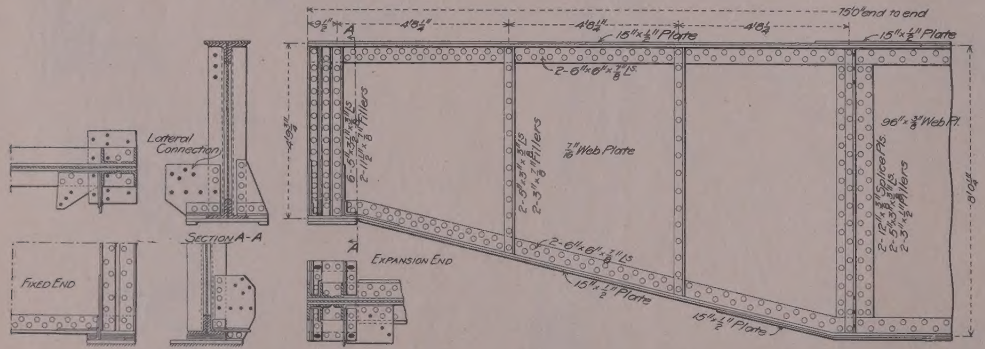
When the first tower and first two spans had been erected the traveler was moved over the second tower. The new columns for this tower were then brought out on flat cars so that the bottom ends of the columns for the west bent were at the east end of the car, and vice versa, in case of those for the east bent. Two sets of lines were then attached to each column for one bent, one set near the bottom of the column and the other set near the top, just below four gusset plates. These lines were then loosely lashed together in pairs about 4 ft. above the columns, and the columns raised from the cars. By loosening the lashings the columns were allowed to swing of their own weight to either side of the track. By lowering the bottom ends of the columns faster than the top the columns were lowered to the ground in a vertical position beside the columns of the old bent, being held in place and partially supported by the lines near the top. The other two columns were then lowered to the ground by a similar process and the transverse bracing, which had been previously lowered to the ground in readiness, was securely bolted in place in each bent, after which the bents were lashed to the old structure.

The new longitudinal bracing was lowered to the ground in readiness to be put in place and the rivets and bolts connecting the top chords of the old trusses with the columns were cut out. Over the top of each end of the floorbeam bearing on the ends of the top chords of the 30-ft. and 60-ft. spans a chain was passed, one end going down on the inside of the truss, under the top chord, and up on the outside, the other end going down on the outside of the other truss, under the top chord, and up on the inside to meet the first end directly over the center of the floorbeam, the whole forming a rough figure 8. In these slings the ends of the trusses, with the track intact, were raised about 6 or 8 ft. above the tops of the columns. The tower bracing having been removed, the old bent was picked up bodily and lowered to the ground on the inside of the tower. The new bent was then raised and placed on the pedestals, from which the old one had just been taken. Across the tops of the new columns were bolted two I-beams of a depth equal to the difference in distance from base of rail to the bottom of the top chords in the old trusses and from the base of the rail to the bottom of the girders in the new structure. The trusses were then lowered to a bearing on these I-beams. The other bent was changed by a similar process and the tower bracing bolted in place immediately.

After the old bents had been taken apart and lowered to the ground the traveler was moved back to the center of the third span which was 60 ft. in length. The girders for this span riveted together with the ties framed and in place on them ready for the rails, were loaded on cars and taken out on the viaduct until they were approximately over the position they would finally occupy in the structure, and were then raised about 4 ft., releasing the cars, which were run back to the shore. The rails and ties were then removed from the 60-ft. span beneath the girders. The wooden stringers were cut at the ends of the span and securely lashed to the trusses in the center. The whole span with the stringers still in place was then raised and lowered to the ground intact, where it could be cut apart as opportunity presented. After removing the I-beams used to support the trusses on top of the columns, the girders were lowered to place and the rails spiked to the ties already on them. Next the traveler was moved to the tower just erected and the 30-ft. span over the tower replaced in the manner just described, except that it was necessary to cut the old trusses apart and lower them one at a time. The traveler was then moved ahead to the next tower and the operations just described were repeated.

Only about 100 ft. of track on each side of the viaduct was necessary for traveler runs, as after a tower with the 60-ft. and 30-ft. spans had been renewed, those portions of the tracks beside the new spans could be taken up and relaid in front of the traveler in the direction in which the work was progressing. The surface for these tracks was constructed of old ties and stringers from the viaduct except in crossing the stream where the tracks were carried on small timber bents.

The upper sections of the columns supporting the channel span of girders could not be put in place until the old trusses had been removed, on account of plumb posts in these trusses. The girders were therefore lowered between the trusses of the old span to a bearing on falsework erected for that purpose and the track was transferred to them. The towers were erected as high as the splices in the columns. The old trusses, which were supported by timbers across the girders, were then taken down and the girders jacked up sufficiently to admit placing the upper sections of the columns under them, after which they were lowered into place and the remaining tower bracing put in place.



Details at End of 75-Foot Span of Ashtabula Viaduct.

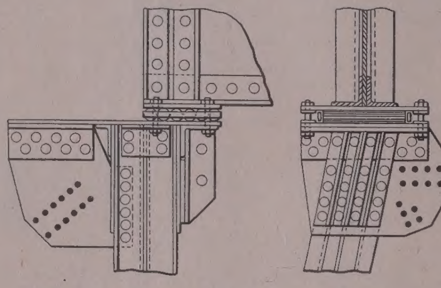
A gallows frame was built on the east abutment to handle one end of the east span, the traveler being used to handle the other end.

The rivets were all hand driven. Scaffolding for gangs driving rivets in the bracing of the towers was supported on 4x6-in. beams about 40 ft. long hung from the ties or guard rails by small lines rove through two-sheave blocks. Riveting on the towers was always started at the top where three beams were necessary, one in the center of the tower and one on each side. At the bottom, owing to the batter of the columns, four beams were used. Two gangs worked on the same scaffold at each tower, each gang having one side and one end to drive. The two gangs usually finished corresponding points at the same time and, when ready, both gangs worked at lowering the scaffold to the next point. The heaters worked on hand-car stands level with the deck of the viaduct, or on the ground, or on a few planks laid across the level bracing in the tower convenient to the riveters. A gang of four men including the heater average 150 ⅞-in. rivets per day of eight hours. On a close inspection about six per cent. of the rivets were cut out. The work throughout was done in a very satisfactory manner. The old bridge iron was picked up and loaded on cars by a small derrick car which was also used to pick up and load the timber used in the traveler.

The record of erection shows that the first bent was placed in position on July 18, 1904. The first new span was placed in position on July 19. The last bent was completed August 29, and the last span was put in position on September 7. The last rivet was driven in the viaduct on September 29. The total weight of the viaduct is about 1,300,000 lb., and it was erected by an average force of thirty men. The viaduct was designed and constructed under the direction of the Engineering Department of the New York, Chicago & St. Louis Railroad. Mr. E. E. Hart, chief engineer and Mr. Albert J. Himes, engineer of bridges. The viaduct was built by the King Bridge Co., and erected by the Pittsburg Construction Co.

The Cost of Railway Operation.

The increase in the cost of railway operation is well shown by figures compiled by Mr. H. T. Newcomb. In 1899 it cost $856,968,999 to operate the railways of the United States; in 1903 the same expenses amounted to $1,257,538,862, an increase of $400,569,863. In 1899 railway labor, exclusive of salaried employees, received $481,264,109; in 1903 the same classes received $720,580,923, an increase of $239,316,814. In 1899 the fuel used by locomotives cost $77,187,344; in 1903 it cost $146,509,031, an increase of $69,321,687. Comparing operating expenses with work done, it appears that in 1899 for every dollar expended for operation the railways were able to carry 17 passengers and 165 tons of freight one mile. In 1903 the passenger mileage for each dollar expended in operation amounted to 16.6 and the freight mileage to 138. Each $1 of operating expenses in 1899 brought in $1.53 in revenue, not including that from miscellaneous services, while in 1903 it brought in $1.38 only.

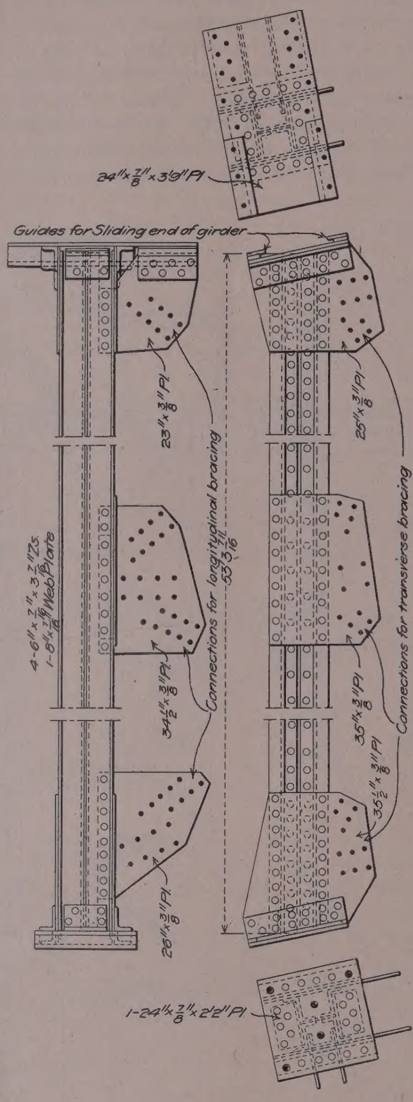


Roller Bearing for Long Spans.

The Transandine Ry. has been completed for a distance of 34 miles and formally opened. It begins at an elevation of 2,664 ft. and terminates at 7,221 ft.

An Endurance Test of a Gas Producer.

An endurance test of a gas producer plant was run for 24 consecutive days not long ago at the St. Louis fuel-testing station of the U. S. Geological Survey. The trial was under the direction of Prof. R. H. Fernald and was rendered possible by the gift of 150 tons of screened Illinois coal from the Donk Bros. Coal & Coke Co. The average of six analyses of this coal showed 14.68 per cent. moisture, 30.98 per cent. of volatile combustible, 42.93 per cent. of fixed carbon, and 11.41 per cent. of ash including 1.33 per cent. of sulphur. The British thermal units per pound of dry coal were 12.343.



One-Story Trestle Column.

This test was made in the plant in which all the Government fuel tests have been conducted since October, 1904. This installation consists of a Taylor pressure producer gas plant of 250 h.p. capacity, furnished by R. D. Wood & Co., of Philadelphia, and a vertical three-cylinder, single acting Westinghouse gas engine of 235 h.p. capacity operating on producer gas. The engine is belted to a 175-kw. Westinghouse generator. The electrical energy developed during this test was dissipated through a water rheostat, designed to readily control the load upon the engine.

The coal was broken to about 3 in. egg size and delivered to the charging floor of the producer by a belt conveyor. It was charged to the producer at intervals varying from 25 to 30 minutes. The weight of each charge was 150 lb. The hopper through which the coal passed to the producer is a double seal hopper with bell and cover plate. The producer was charged by hand. The bell is so designed that the coal is evenly distributed over all portions of the fuel bed, which was kept in uniform condition by hand poking from the top about every half hour.

The gas left the generator at an average temperature of 644° F., and passed through a water-seal dust collector and then to the scrubber. From there the gas passed directly to a centrifugal tar extractor which removed the greater portion of the tar left in the gas. It was then delivered directly to the holder. No further attempt was made to purify it, since experiments at this testing plant have proved conclusively that sulphur carried in the gas has no injurious effect upon the engine. From the holder the gas passed through a meter which has a capacity of 30,000 cu. ft. per hour, on its way to the engine cylinders.

During this entire test calorimetric determinations of the heat value of the gas were made every 20 minutes, and volumetric analyses were made every 2 hours. The average heat value of the gas for the entire run was 156.1 B.t.u. per cubic foot. This gas contained no hydrogen disulphide, 9.2 per cent. carbon dioxide, no oxygen, 0.4 per cent. ethylene, 20.9 per cent. carbon monoxide, 15.6 per cent. hydrogen, 1.9 per cent. methane, and 52 per cent. nitrogen.

Observations relating to the tar extracted during this test are of special significance, as it has often been stated that no plant which separates the tar mechanically could run more than 5 or 6 days without shutting down. The total tar extracted during this test amounted to 14,950 lb. or about 143 lb. of tar for every ton of coal burned in the producer. This tar did not contain over 10 per cent. of water.

As the plant was designed for general test purposes, the passages through which the gas was obliged to pass were far more tortuous than would have been the case in a plant installed merely for the production of power. In passing from the dust collector to the scrubber, the gas was forced to make three right-angle turns and pass through a water seal valve, traversing a distance of about 20 ft. instead of 3 ft., as would have been the case in an ideal arrangement. Owing to the deposit of tar in the water seal valve, the test was brought to a close after 24 days. Without this unfortunate combination of piping, more notable endurance records should be made than the 24-day test here recorded.

The ashes were removed about once every 48 hours without shutting down the plant. This was accomplished by simply reducing the pressure under which the producer was operated, and running the plant on the suction basis during the hour required for removing the ashes. The men worked with entire ease and comfort during this period.

The engine ran in perfect order at all times during the period of 24 days and at the end of the test was found in unimpeachable condition. Even a cleaning was not necessary. The producer plant was also found in excellent condition.

Owing to the fact that final calibrations of some of the instruments used in this test have not been received, the official horsepower carried during the test and the dry coal required per brake horse-power per hour cannot be given. The approximate figures show, however, that an average horse-power of 227 was used during the test, and an average of 1.39 lb. of dry coal consumed per brake horse-power per hour.

Telephone Lines can be protected from interference by wireless messages by connecting condensers of 0.002 to 0.005 mfd. capacity between each side of the line and the earth, at or near the lightning arrester where the sparking takes place. Telephone lines in the neighborhood of wireless telegraph stations are frequently disturbed by the latter's operations.

The Efficiency of Surface Condensers.

A brief reference in these columns a few weeks ago to a paper on the efficiency of surface condensers read by Prof. R. L. Weighton before the Institution of Naval Architects has resulted in so many inquiries for more information concerning it that the following much condensed abstract is here printed. The paper is based on many diagrams and voluminous tables which cannot be condensed, and the reader who desires a full statement of the author's reasons for his conclusions must accordingly consult the unabridged text published by the Institution. The tests were made on three "Contraflo" condensers and one of the ordinary type.

The old type condenser has a total condensing surface of 170 sq. ft. The tubes have an external diameter of ¾ in. and a length of 4 ft., and are pitched 1 7/16 in. center to center. The condensing water enters at the bottom and leaves at the top, after circulating twice through the tubes, thus giving an effective tube length of 8 ft.

No. 1 condenser of the new type contains 170 sq. ft. of surface. It has tubes ¾ in. external diameter by 4 ft. long, pitched 1⅛ in. centre to centre. The condensing water circulates five times through the tubes, thus giving an effective tube length of 20 ft. This condenser proved itself much too large for even the maximum quantity of steam the engines could take, and No. 2 was therefore made, containing only 100 sq. ft. of surface, and having tubes ⅝ in. external diameter by 4 ft. long by 1 in. pitch. The water was at first made to circulate eight times, thus giving an effective tube length of 32 ft. Alterations were subsequently made to the condenser doors, and a circulation of four times was adopted, giving an effective tube length of 16 ft. No. 2 condenser proving also of very ample size for the amount of steam available, it was decided to build a still smaller condenser of exactly the same transverse section as No. 2, but with tubes only 2 ft. 6 in. long, giving a surface of 62 sq. ft. This is No. 3 condenser. The water circulating four times gives an effective tube length of 10 ft. The condenser is divided into three compartments by two diaphragms, somewhat inclined to the horizontal, and the water of condensation in each of the three compartments is drained off directly from that compartment, so that the surfaces in the lower compartments are unimpeded in their condensing action by water from the upper compartment flowing over them. As the major part of the condensation, even at fairly high rates of condensation, is completed in the highest sections of surface on which the steam first impinges, the importance of this feature is apparent, and its influence will be seen on the results.

Other features of the type are the abolition of the steam space and the substitution of a mere passage of such shape and section as will secure the distribution of the steam over the whole length of the tubes, the tubeless passages connecting the compartments with each other, and generally, the means adopted for promoting uniformity of flow of vapor over the whole tube surface, and throughout the whole condenser section. Care was taken that in all cases the tubes were in a clean state when the trials began, so that the different types might be on the same basis in this respect.

A very large number of trials were made, both on the old and on the new condensers, with the air pump attached to the condenser of the experimental engines in use. This pump is of the usual vertical single-acting bucket type, driven by levers from the low-pressure crosshead in the fashion common in marine practice, and is 8½ diameter by 9 in. stroke. Throughout these trials the engines were run at a standard speed of 140 r.p.m., thus fixing the pump capacity per unit time. Subsequently it was decided to install an air pump driven independently of the main engines, with a view to test the effect on condenser performance of variations in air pump capacity, and of working on the so-called "dry" air-pump system. A set of three-throw vertical air pumps, electrically driven and of the Edwards type, was therefore connected to the condenser. These pumps were purposely made of somewhat abnormal size, and the motor was capable of a very wide range of speed. Each pump was 8 in. diameter by 8 in. stroke, and so arranged and fitted as to be capable of being worked single, double, or triple, in series or in parallel and with or without a cold water spray in the base of the air-suction pipe.

The condenser results are in no degree due to air pump capacity, either large or small, except where special mention is made of the fact. At all except very low powers the original single air pump was capable of giving as high a vacuum efficiency as the three new pumps at their maximum capacity, and one pump of the latter, working at a capacity of 0.7 cu. ft. per pound of steam condensed, was practically as good as all three pumps at their maximum speed.

In each case the condenser under trial was used to condense the exhaust steam from the experimental engines. The conditions for the different condensers were as constant as possible. The steam was superheated to an average of some 50° F., as ascertained by a thermometer on the high-pressure cylinder steam chest. The maximum steam pressure was 210 lb. per square inch. There was little or no appearance of water at any of the piston or valve-rod stuffing-boxes. The intention was, that while every condition once fixed upon should be kept as uniform and constant as possible throughout all the trials of a series, the general conditions should be such as to represent fairly those occurring in practice with a condenser attached to a reciprocating steam engine. The number of individual trials made amounted in all to some 350.

For a given condenser the engines were adjusted for any required rate of condensation (W/S). Then a series of trials—generally five—were made at this rate with different quantities of condensing water up to the maximum available. Great care was taken that the intervals between trials were of sufficient duration to permit of the new conditions attaining stability in all cases. For each rate of condensation (W/S) a separate series of trials were made with varying quantities of condensing water (Q/W). The condensed steam and the condensing water were both carefully measured by the calibrated appliances attached to the engine testing plant, and all the observations were seen to by trained observers, and were subsequently checked by the author before being recorded as correct.

The condensing water was obtained direct from the city mains, and its temperature, therefore, was beyond control. As, however, the trials extended over summer and winter, the inlet temperature ranged from about 40° to 65°, and this enabled the effect of variation in inlet temperature to be determined with accuracy for intermediate values, and for values somewhat exceeding the maximum.

The possibilities of air leakage in these trials were considerable. Not so great, of course, as they would be in a large and complicated system, with, say, many auxiliary engines exhausting into it, but greater than in the case of a single condenser attached to a single engine in a compact fashion with few pipes and joints. The old type of condenser had the advantage in this respect on these trials. Clearly, unless it were possible to reduce the air leakage to, and maintain it at, some controllable minimum fairly uniform in amount for all the trials, the results would show no consistency, and any attempt at comparative analysis of the results would be hopeless. No series of trials was therefore entered upon until the leakage was normal, and under the control of the air pump to a degree which will be seen later on. Two vacuum gauges as well as a mercury column were used on each condenser, all having been calibrated from a standard instrument which in its turn had been standardized in the National Physical Laboratory. The readings of the gauge at the condenser top (V_t) were not always in absolute accord with those of the gauge at the condenser bottom (V_b). As the vacuum at the condenser top may be expected to control that in the engine cylinder, this was taken as the true vacuum. Care was taken that no such thing as "induced" reading on a gauge could occur, by fitting a curved projecting nozzle to the gauge-pipe inside the condenser, and turning it round in all directions and observing the effect while a trial was in progress. In no case was the slightest induced effect observed.

Analysis of Results.—Broadly speaking, the feature in these results is the considerable difference in efficiency between the two types of condensers when both are worked under exactly the same conditions. For instance, a vacuum of 28 in. may be attained in the old type at a water expenditure of forty-three times the feed water, while the new type No. 2 requires only twenty-four times the feed for the same inlet temperature. Further, under these conditions the old type was condensing at the rate of about 10 lb. per square foot, while the rate in the case of the new type was some 20 lb. per square foot.

There are several possible criteria of efficiency in a condenser according to the point of view. In this connection the factors directly involved are the following: Steam condensed per square foot of surface (W/S); water required per pound of steam (Q/W) vacuum attained; hot-well temperature; power expended in producing the vacuum, i. e., on circulating and air pumps; and size, weight, and first cost of condenser. The author takes it that the condenser will be the most efficient which, with given water inlet temperature, air leakage, and air pump capacity, maintains a given vacuum with the smallest condensing surface per pound of steam condensed, the smallest quantity of condensing water per pound of steam condensed, the smallest relative power expended in driving the circulating and air pumps, the highest hotwell temperature, and the smallest weight and first cost in relation to the steam condensed. Another way of putting it would be that that condenser is the most efficient which, all other things equal as enumerated above, maintains the highest vacuum.

The plotted results with the old type of condenser show that when the rate of condensation (W/S) is increased, other things equal, the quantity of water per pound of steam (Q/W), to maintain a given vacuum must also be increased. This is obviously due to a falling off in surface efficiency as the condensation is increased. The outlet temperature has a different value for each value of (W/S) at a given vacuum. Further experiments were made with higher speeds of condensing water and also with cores in the tubes. Although the results indicated a distinct improvement, they were still much inferior in surface efficiency to those obtained with the new condenser, and the thermal efficiency was, of course, unaltered.

With the new type one curve suffices to relate vacuum with (Q/W) at all condensation rates up to W/S = 20. There is a certain amount of irregularity amongst the observation spots, but no general or regular deviation for any one rate of condensation, and it is not possible to draw aught but one curve through them. This single curve is characteristic of this type of condenser. It always gives it, whatever may be the proportions of the condenser as regards surface-section ratio, or the conditions of working. The size of condenser has no effect—up to a value of at least W/S = 37, at which No. 3 condenser has been worked—on the quantity of water required for a given vacuum. Whatever may be the condensation rate the outlet temperature is constant if the vacuum is kept constant by variation in quantity of condensing water, the inlet temperature being, of course, assumed constant. In other words, surface efficiency remains unaltered at constant vacuum.

The outlet temperature (t_o) follows the vacuum temperature (t_v) closely under the test conditions and t_o does not fluctuate up or down as W/S is altered, as is the case with the old type, any fluctuation in t_o being entirely due to variation in t_i. Further, t_o for the new type is much higher on the whole than for the old type, and under the best conditions it closely corresponds with t_v, sometimes rising slightly above it, according to the inlet temperature.

Surface efficiency is at the root of all efficiency in a surface condenser. That condenser is the most efficient in which each square foot of surface transfers in given time, and conditions, as to water supply, etc., from the steam to the water, the largest number of heat units. This will, moreover, be the condenser which will not only register the highest vacuum, but will maintain it at the least cost in condensing water, and with the smallest surface and cubical capacity per pound of steam condensed. It will also be the condenser which, in given conditions, will yield the highest hotwell temperature. In order that a surface may thus act, it is necessary that the steam should have free access to, and should pass over sufficient surface on the one side, and that all the condensing water should come into direct and efficient contact with the surface on the other side. This clearly cannot be the case if on the steam side practically the whole surface is continually subjected to showers from the water of condensation, or if the steam can short-circuit any material amount of the surface, nor can it be the case on the water side if the condensing water flows through the tubes in unbroken cylindrical streams, the peripheries of which streams alone come into actual contact with the tube surface, and a greater or less proportion of water-core passes through without efficient contact at all. Hence the augmented efficiency of the surface as a whole, due to the early interception and removal of the feed water, the provision for promoting steam circulation, and the adoption of a suitable ratio between the surface and the water-carrying section of each tube element by the introduction of a solid displacing core in the tubes or otherwise. The cores used on these trials were merely lathes of hard wood rough from the saw. They were of triangular section and about 2 in. longer than the tubes, and were simply inserted in the tubes without any fastening whatever.

Economy of condensing water is one very important result of enhanced surface efficiency. Economy of water is important from several points of view. First, as in the case of land installations, water may itself have to be purchased. Secondly, it has to be pumped through the condenser, and any saving in water means, other things equal, power economy in vacuum production. Third, water may have to be cooled for repeated use, and in this case surface efficiency of condenser has a double effect. Not only is there less water to be pumped, but owing to its higher outlet temperature there will be a greater mean difference between the temperature of the water to be cooled and the air which cools it, and hence cooling towers will be more efficient, and may therefore be of smaller size for given power.

Another important result of enhanced surface efficiency is, of course, economy of condensing surface. Owing to steam space being dispensed with in the new type, a given surface is contained in less capacity of condenser shell. These two features conduce to economy of weight and capacity. From the point of view, therefore, of weight and space occupied, the new type of condenser has important advantages which would seem to render it peculiarly adapted for use on board ship, and specially so for all classes of war vessels, in which both weight and space are of supreme importance. In the case of marine condensers, economy of condensing water is of itself of secondary importance, but economy of pumping power, of weight and space occupied, degree of vacuum maintained, and hotwell temperature, are all of great importance. Of all the condensers tested in these trials, the proportions of No. 3 seem best suited to marine conditions, inasmuch as this condenser, at the cost of some sacrifice in condensing water, as compared with No. 2, maintains any vacuum up to the highest, with considerably less surface than is the case with No. 2, and with very much less than in the case of the old type.

The dictates of heat economy prescribe that the water resulting from condensation shall not be cooled any further than is necessary for the production of a given vacuum. If, therefore, any required vacuum is obtained without the necessity of cooling the water unduly, this would, other things equal, be an advantage. But as the author interprets the results of these trials, the other things are not, and cannot be, equal. Not only is it possible to maintain a vacuum, which may, if required, be as high as 29 in., with an air pump of not unusual capacity, with a hotwell temperature of 3° to 5° above that due to the vacuum, but to do this with less expenditure of condensing water and less condensing surface than would be the case were the conditions such as to yield a hotwell lower in temperature. In other words, the higher hotwell temperature, and the smaller amount of condensing water and surface, are both due, the former entirely and the latter partially, to the same cause, viz., the compartment drainage of the condenser. The enhanced thermal efficiency of the new type as compared with the old type is undoubtedly due to the measures adopted in the former for removing the water of condensation as soon as possible after it is thrown down from the steam, thus preventing its trickling over the comparatively cold tubes towards the bottom of the condenser. Experiments have shown that at all except very high rates of condensation, or very small quantities of condensing water per pound of steam, the greater proportion of the condensing work is done by the surface situated in the uppermost compartment. The great mass of the feed-water is, therefore, withdrawn from the condenser at a temperature sensibly equal to that obtaining in the top compartment of the condenser, and without passing over the cooler compartments lower down, and specially escaping the lowest compartment of all, which is thus reserved as an efficient air-cooling section.

The hotwell temperatures of the old type are from 10° to 15° lower than those for corresponding conditions in the new type for all degrees of vacua exceeding 26 in., and the presence of cores in the tubes has very little, if any, effect upon the hotwell temperature. Experiments were made with the condensing water entering at the top and leaving at the bottom of the condenser, and the results indicate that the water ought to enter at the bottom and leave at the top.

The absolute pressure in these condensers is practically uniform throughout the interior. But the temperature is not uniform throughout. It is always higher at the top than at the bottom. The absolute pressure, therefore, i. e., the vacuum, must be a compromise between that due to the top and that due to the bottom temperature. As a matter of fact, in air-tight systems the vacuum recorded is generally somewhat higher than that corresponding to the top temperature, but is not so high as the bottom temperature would indicate, especially at high vacua.

Conditions are conceivable in which a given vacuum might be too dearly purchased. Leaving out of account for the moment all question of the first cost or weight of the vacuum-producing appliances, including the condenser and pumps, as well as any commercial value attached to the condensing water, we have on one side of the account the power expended in maintaining the vacuum, and on the other side the power realized from it. Obviously, if a given vacuum should cost more in power for its attainment than it returns in the shape of power due to it in the engines, it would be bad policy to work at such a vacuum. On the above basis the power cost of a vacuum will comprise the power required to drive the air and circulating pumps. The power absorbed by the air pump will clearly depend upon its size and speed, but so far as degree of vacuum is concerned, the power seems to be practically independent of the vacuum, at least for the Edwards type of pump and for vacua ranging between 26 in. and 29 in. If there is any effect at all, it is so small in a comparative sense as to be negligible in practice. For a given condenser and air pump capacity for unit time, the power required to drive the air pump may, therefore, be taken as constant, whatever be the degree of vacuum, within the limits above mentioned.

As regards the power absorbed by the circulating pump, this will, of course, depend upon several factors, according to the circumstances of each individual case, but so far as the essential circumstance is concerned, viz., the production of different degrees of vacua in a given condenser, the power will depend on two factors only, the quantity of condensing water, and the head or pressure against which it is propelled through the condenser. The power cost of circulating the condensing water will, therefore, be proportional to the product of the pounds of water circulated per minute and the resistance—expressed in feet of head—against which it is circulated.

In these tests the use of tube cores raises the highest attainable vacuum, in the conditions obtaining, by nearly ½ in., but at a greatly enhanced cost in pumping power. The most economical vacuum, in its widest sense, at which to work in any given case depends chiefly on the engines, but it also depends to a considerable extent on the condenser. In so far as it depends upon the steam consumption in the main engines, it is beyond the scope and purpose of this paper. In so far as it depends upon the condenser, it falls to be dealt with here. The most economical vacuum, in its widest sense, will obviously be that vacuum with which is associated the minimum steam consumption per horse-power developed. Whatever may be the value of this particular vacuum in any given case, it is clear that it cannot possibly exceed that degree of vacuum beyond which the pump power absorbed in increasing the vacuum exceeds the power return in the main engines due to that increase. This much at any rate is clear, without any reference whatever to the consumption of steam in the engines utilizing the vacuum. In the region of extremely high vacua increments of vacuum are attained at increasing power cost in circulating the condensing water, and it therefore becomes a matter of importance to ascertain, for given circumstances, the limit of vacuum beyond which the vacuum cost exceeds the vacuum return. Inasmuch as this return depends on the engines, it follows that their proportions and type must be factors involved in the economics of vacuum production.

When the condenser is used in connection with a steam turbine, the limit in economical vacuum production is practically identical with the highest attainable vacuum, and that when used in conjunction with reciprocating quadruple-expansion engines of the stated proportions, the limit is slightly less than the maximum vacuum, but the difference between the two cases is not very striking.

The speed of circulating water in the tubes varied in these trials from 1¼ ft. to 4½ ft. per second with no cores, and from 1¾ ft. to 6½ ft per second with cores, the corresponding maximum resistances being those due to heads of 10 ft. and 32 ft. respectively.

It would appear from this, that, so far as economy in vacuum production is concerned, the head against which the condensing water is circulated may be considerably higher than is often at the present time considered desirable or admissible. As regards the economics of vacuum utilization, the author is anxious not to complicate the condenser question with it.

As already mentioned, a very large number of trials were made with the pump capacities and arrangements and conditions, varied in every possible way. These trials yielded results all pointing to the same conditions. First, that when the system is fairly air-tight, a pump capacity of 0.7 cu. ft. per pound of steam condensed is as good as anything larger; but, second, when the air leakage exceeds a certain amount, larger pump capacities are necessary for the maintenance of the vacuum previously existing; third, that there is no apparent advantage in working ordinary pumps on the compound principle.

It is perhaps necessary to point out that in these trials reductions in rates of condensation, i. e., in power, were obtained by increased expansions, or by lower initial steam pressures, the revolutions being retained constant throughout. The result was that at the lower powers the receivers of the two last cylinders were working at pressures below the atmosphere. This condition of matters was always associated with a marked increase in the quantity of air discharged by the air pumps, and a tendency for the vacuum to fall, due no doubt to increased air leakage at the stuffing boxes of the receivers and cylinders. Although these stuffing boxes were packed with special packing and were kept in good condition, it was quite impossible entirely to prevent air leakage occurring in this way. At full power when the low pressure receiver pressure will be slightly above the atmosphere, 0.7 cu. ft. capacity maintains a given vacuum, at quarter power the same vacuum needs an expenditure of 6.5 cu. ft. to maintain it. It was always in these trials found that at high powers the vacuum was determined by the condenser temperature, while at lower powers it was determined in an increasing degree by the air pressure in the condenser, and at the lowest power of all it had little relation to the temperature, but was determined solely by the amount of air leakage and the capacity of the air pump to overcome it. All this for extremely high vacua, say, above 28 in. At vacua below that figure the effects of even considerable air leakage are not so noticeable.

The effect of the "dry" air pump system in raising the vacuum obtainable from a given expenditure of condensing water will be something considerable; but, of course, at the cost of increased pump capacity in relation to the steam condensed.

Conclusions.—From the foregoing results the following conclusions are drawn:

(1) It is conducive to efficiency in a surface condenser that the water resulting from condensation should be intercepted and removed from the condenser as soon as possible after it is formed.

(2) It is conducive to efficiency that the condenser capacity should be a minimum consistent with the accommodation of the necessary surface, and that the design should be such as to secure a pervading and uniform flow of vapor throughout the condenser section, thus utilizing the whole of the condensing surface provided, as well as obviating stagnant recesses in which air might be retained.

(3) It is conducive to efficiency that the condensing water should travel at a fairly high speed through the tubes, and that it should enter at the bottom and leave at the top of the condenser.

(4) With suitable condenser design and proportions, the temperature of the condensing water at the discharge point may be equal to, or slightly higher, than the temperature due to the vacuum. This holds true for vacua up to slightly over 29 in.

(5) With suitable condenser design and proportions, the temperature of the hot well may be from 3° to 5° higher than the temperature due to the vacuum. This holds true for vacua up to slightly over 29 in.

(6) With suitable condenser arrangements and a reasonably air-tight system there is nothing gained in efficiency by the use of air pumps exceeding in capacity 0.7 of a cubic foot per pound of steam condensed up to a limit of close upon 29 in. vacuum. For vacua exceeding this limit, or for cases in which air leakage is considerable, the air pump capacity must be increased, or else the vacuum efficiency will fall.

(7) With suitable condenser design and proportions, and in conjunction with "dry" air pumps, a condensation rate of 20 lb. of steam per square foot of surface per hour will be maintained in association with a vacuum of 28½ in., and a quantity of condensing water equal to twenty-four times the feed-water, at an inlet temperature of 50°.

(8) With suitable condenser design and proportions, and in conjunction with "dry" air pumps, a condensation rate of 35 lb. of steam per square foot of surface per hour will be maintained in association with a vacuum of 28½ in., and a quantity of condensing water equal to twenty-eight times the feed-water, at an inlet temperature of 50°.

AN OUTFALL SEWER presenting unusual characteristics is approaching completion at Plymouth, England. An area of 1,930 acres is drained by this sewer, which is 4x2⅔ ft. at the head and 6½ ft. in diameter at the end. Nearly all of it was constructed by tunneling through limestone and shale, the lining consisting of 6 in. of concrete and 4½ in. of brickwork. The sewer discharges into a covered tank 1,000 ft. long, 34 ft. wide and 35 ft. high, divided into three basins, in which the sewage will be stored for discharge into the sea on ebb tide. The sewage will be delivered from the tank through two lines of cast-iron pipes, 72 and 48 in. in diameter, respectively, ending in 80 ft. of water in a swift tidal way. Owing to a regulation of the Admiralty, it has been necessary to excavate a trench 20 ft. wide and 9 to 12 ft. deep in which the pipes are bedded in concrete, and this work has been so troublesome that progress was slow. The works were designed by the late James Mansergh and have been executed under the direction of his successors.

The Page Bascule Bridge on the Santa Fe Improvements in San Francisco.

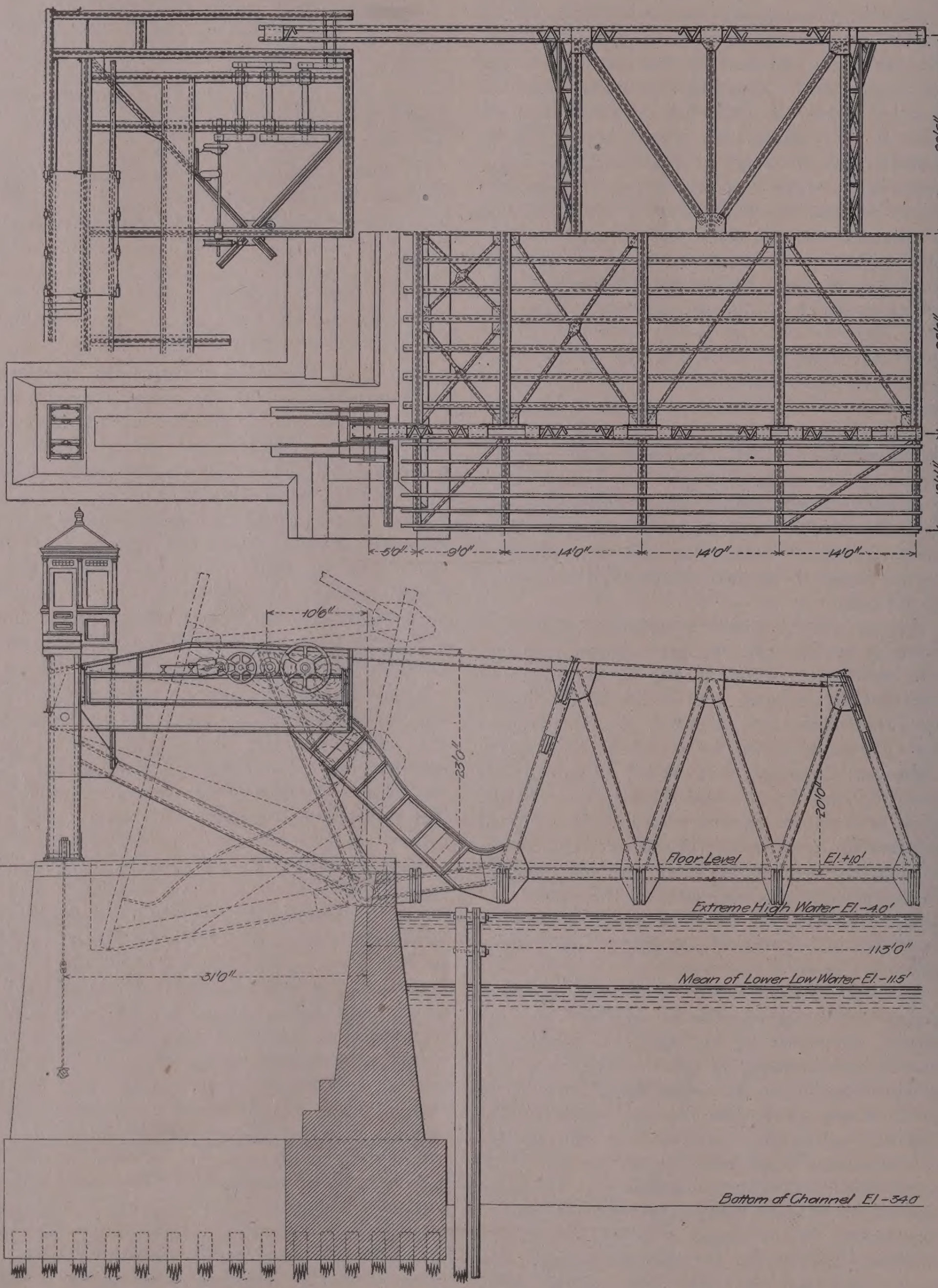
In connection with the China Basin improvements of the Atchison, Topeka & Santa Fe Ry. Co., in San Francisco, it became necessary to build some type of a movable bridge across a channel at the foot of Third St., in that city. The bridge had to be built at the expense of the railroad company, but on completion was to be turned over to the city for maintenance and operation, and the Board of Public Works of San Francisco therefore desired to approve the type of structure that should be erected. After the consideration of various plans by the railroad company, decision was made to recommend to the Board of Public Works the construction of a Page bascule bridge of the Page type, described in detail in this journal on April 27, 1901. Owing to the fact that its floor was to be only 5 ft. above high tide, it was necessary to adopt what is known as the through, or high-truss, design. Mr. E. C. Grunsky, city engineer of San Francisco, recommended to the Board of Public Words the adoption of the proposed design as being the most suitable to fill all the conditions at the particular place where a bridge was required.

Previous to adopting plans for the sub-structure, a very complete set of soundings had been made, which showed a reasonably hard mixture of sand and clay at an average depth of about 44 ft. below city datum, the latter being 4 ft. above extreme high tide. Above this clay and sand was an average of about 25 ft. of mud. After the consideration of various plans, it was finally decided to put in a Wakefield sheet-piling cofferdam, dredge out all the soft material with a clam-shell bucket, then drive piles and cut them off at about 37 ft below datum and build concrete abutments on these piles. The concrete was to be placed under water over the piles to 27.5 ft. below datum, after which the cofferdam would be pumped out and the balance of the concrete placed in the dry. This plan was carried out and proved to be a success.

Work was commenced on the sub-structure in April, 1904. On the morning of Dec. 10, after the south abutment had been completed, a large crack was discovered at the intersection of that abutment and one of its wing walls, and on further investigation it was found that the rear end of the wing had settled about 4 in. As the piles had been uniformly driven over the whole foundation and a complete record kept of them, it was difficult to account for the break and settlement until it was learned later in the day that an earthquake shock had occurred during the night, which a thorough investigation showed was the cause of the movement that had taken place. To determine the condition of the foundation, the end of the wing wall was loaded with 65 tons of steel rails. These rails were allowed to remain on the wing wall for about a month, during which time no further settlement occurred. The crack was then filled with cement grout, the wall leveled up to its proper elevation, and put in condition to receive the superstructure.

The bridge is of the bascule type, divided into two equal leaves, which are counterbalanced and operate on trunnions mounted in the abutments. The bridge has a roadway 36 ft. wide in the clear, and one sidewalk 8 ft. wide in the clear. The length of the bridge, center to center of end posts, is 175 ft.; the distance between trunnions, 113 ft. The bridge offers a clear channel 75 ft. wide, when open, the crossing being at an angle of 77 deg. The most important feature of the design is that all movable parts are theoretically in balance during operation, the only power required being that to put the bridge in motion and overcome the effect of wind and friction.

The girders carrying the counterweights are hinged on a pin near the top of the vertical end posts, and the opposite end of the girders rest on a shaft, which carries the load to rollers running on the track girders. The main driving pinion is keyed to this shaft between the rollers, and engages in a rack running along the center of track girders. To the end of the roller shaft on the inside of the counterweight girder is attached the main driving gear, from which a train of gears lead down to the motor operating the leaf. The gearing and motors are supported on longitudinal girders, these being connected to cross girders, which are attached to the inside counterweight girders; the machinery, motors, and the girders supporting them thus serve as part of the counterweights. The remainder of the counterweight required on the inside girders consists of concrete placed on buckle plates riveted to the machinery girders. The counterweight on the outside girders consists of cast-iron blocks bolted to the webs, the blocks being so distributed that the load is practically equal on each of the rollers. The bearings for the trunnion, the roller shaft and the rollers on the shaft are phosphor bronze, while those for the rear pin on which the counterweight girders are hinged and all the shaft bearings are Babbitt metal.


20'6"
20'6"
10'1½"
5'0"
9'0"
14'0"
14'0"
14'0"
10'6"
23'0"
20'0"
Floor Level
El.+1.0'
Extreme High Water El.-4.0'
113'0"
Mean of Lower Low Water El.-11.5'
31'0"
Bottom of Channel El-34.0'

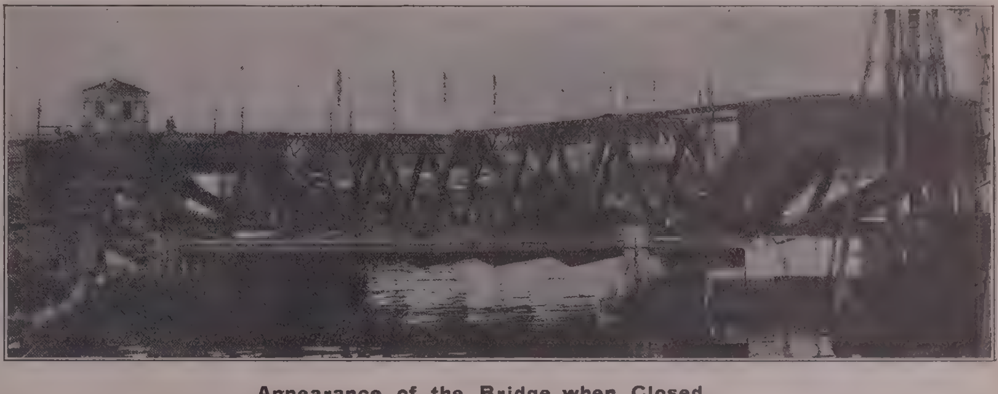
Half Plan and Elevation of Bascule Bridge, San Francisco.

Standard pneumatic railroad gates worked from a house for the bridge tender are used at each end of the bridge to intercept traffic when the bridge is about to be opened, the roadway and sidewalk being absolutely blocked as soon as the bridge begins to open.

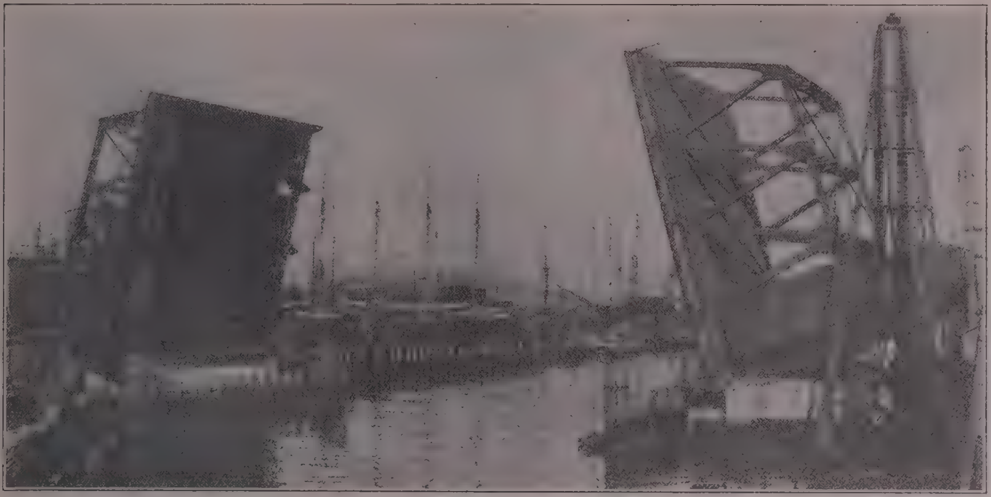
Each leaf of the bridge is operated by two 40-h.p. railway type motors, each pair being connected to a series-parallel controller in the main bridge tender's house, which is mounted above the roadway at one end of the bridge. Wiring connections are made to the motors on the other leaf of the bridge through lead-covered iron-armored submarine cables laid in a trench across the bed of the channel. An indicator consisting of a number of electric lamps is provided in the tender's house and shows the position of each leaf of the bridge both day and night, by lighting or extinguishing the different lamps. The lighting and extinguishing of the lamps is accomplished through a specially designed contact device connected mechanically to each leaf. The same contact devices are also connected to two circuit breakers on a switchboard in the tender's house, so that when either leaf of the bridge arrives at its extreme position in lowering or rising, the circuit is opened automatically without any action on the part of the bridge tender. The position indicator and automatic stop are specially desirable in view of the fact that it would necessarily be somewhat difficult for the bridge tender to see the exact position of the leaf on the farther side of the channel.

Each motor driving the raising and lowering gearing is provided with a magnetic brake. A special floor switch is provided in the tender's house, so that the tender by the pressure of his foot, may release the brakes on either or both leaves of the bridge at will. The brakes are applied when there is no pressure on the floor switch. The action of the automatic stop also applies the brakes. The center lock between the leaves is operated by a 3-h.p. enclosed type motor at the end of the leaf of the bridge on which the tender's house is built. This motor is operated through a controller on the switchboard. The position of the center lock is shown to the tender by an indicator similar in design to the one which shows the position of the leaves of the bridge.

The switchboard in the tender's house carries such instruments, circuit breakers, cut-outs and switches as are required on first-class installations of this sort. At the extremity of each of the leaves and outside the roadway is mounted an electric lantern, showing red to the river, in order to warn away navigation when the bridge is closed, and to show the position of the point of the bridge when open. Each wire is run in an individual iron conduit, special junction and terminal boxes being provided wherever the line branches or ends. Large junction boxes are provided on each side of the channel where the submarine cables end.



Appearance of the Bridge when Closed.



Page Bascule Bridge at San Francisco, Cal.

While the bridge has been in operation only a comparatively short time, it has been fully demonstrated that the amount of power provided in the motors is more than ample. Tests taken before the machinery and moving parts had time to get smoothed up showed that each leaf requires approximately 35-h.p. to raise, or lower, the complete motion being performed in 24 seconds, with the motors running in multiple; with the motors connected in series less than 20 h.p. was required, and the motion was performed in 45 seconds.

The bridge was designed by Mr. W. M. Hughes, bridge engineer, of Chicago, under the Page & Schnable patents. The American Bridge Co., of New York, were contractors for the superstructure, the steelwork being fabricated at the Lassig plant of that company in Chicago. Messrs. G. P. Nichols & Bro., of Chicago, installed the electrical equipment. The Thomson Bridge Co., of San Francisco, were contractors for the substructure and erection of the superstructure. The plans for the bridge were approved by Mr. A. F. Robinson, bridge engineer of the Santa Fe system. Mr. W. D. Nicholson, assistant engineer of the Atchison, Topeka & Santa Fe Ry. Co., had immediate charge of the construction.

Notes on the Californian Earthquake.

By Carl Leonardt, Los Angeles.

At the present time everybody is working hard to clean out the debris left by the fire. Ruined walls are being pulled down as fast as possible and the hideous aspect of these grimy reminders of former conditions is being rapidly blotted out. The Southern Pacific and Ocean Shore Railroad Companies are rushing the work of tracklaying, not only along the main arteries of the business quarters, but also along the cross streets. This develops as part of a gigantic plan for the rapid cleaning up of the debris from all parts of the burned district. It is estimated that from 10,000,000 to 11,000,000 cubic yards of waste must be removed before devastated territory can be rebuilt. Dumping grounds for this enormous volume of debris must be found outside the city, hence the construction of the temporary steam railroad track along those streets on which the grade is not prohibitive. Alongside these tracks bunkers will be erected to receive the debris delivered by aerial ropeways which will be extended throughout the hill districts, and from which the trains of flat cars will be loaded automatically and hauled off to reclaim the marshes in the southeastern section of the city and beyond.

From the point of view of the architect and builder, my trip to San Francisco was one of absorbing interest. All of my investigations confirmed me in my convictions of the absolute safety of the modern steel construction. The prevailing type of fireproof building in San Francisco is the steel frame, with cement or concrete floors, or expanded metal floors and walls. That will be the type of building undoubtedly in the restored city. Reinforced concrete, such as we have in Los Angeles, would stand the test just as well in every particular, but the materials and labor supply in San Francisco favor the former.

All of the big modern buildings I found little damaged, and capable of being restored immediately and at comparatively little cost.

Perhaps the greatest popular interest centers about the Call building. I examined that first of all. It is perfectly sound and safe. The damage was done through flames soaring up through the elevator shaft, and communicating through their heat to the offices, where the furniture and window casings were burned. I will guarantee to restore it entire within two months for $75,000.

The Monadnock building: The dynamiting of that magnificent building was one of the most absurd and ridiculous features of the whole fire. I helped build that building myself, and I know what it was. But they couldn't destroy it even with dynamite. The floors are still in perfect condition. It can be restored for $50,000.

The Merchants' Exchange building was little damaged, save for the interior finishing, but it is a huge building, and to restore it completely would cost about $125,000.

The Hayward building, fourteen stories high, is a magnificent example of the fine way in which these big buildings stood the test. In many of its offices not even the furniture was injured, although it was directly in the path of the fire. It can be restored for about $25,000. (The fireproofing in this building was the "Prong Lock" system of the Berger Mfg. Co.)

The Fairmount Hotel, contrary to universal report, was little damaged except where the flames spoiled the granite and the huge columns. The damage ought not to exceed $25,000. But the mansions on the hill about it, the Flood, Fair, Crocker and Towne residences, they are nothing but a mass of ruins.

The St. Francis Hotel stood the test well. The furniture caused a considerable fire to rage within the walls, but the building ought to be restored for $75,000.

The Flood building, which experts thought of too heavy a construction at the time of its erection, justified the cleverness of its architect. It can be restored in a very short time [illegible] a cost of about $150,000.

In the Union Trust Company not even the paint on the walls is injured, the safes, vaults and the structure are all right. The damage will not exceed $80,000.

The Crocker building is in fine condition. Although it stands on Market Street, right across from the Palace Hotel and in the very pathway of the flames, among some of the upper offices not even the furniture is damaged. The damage will range about $75,000.

So well did the Market Street Bank building stand the fury of the flames that it could be opened to-day with little more than the restoration of the glass and frames of the windows.

The great Kohl building is another magnificent evidence of the endurance of these structures. I would say that the damage to this building would not exceed $10,000.

With the possible exception of the Call building, which apparently ignited from within, probably none of the other fireproof buildings would have been injured save for having been surrounded on all sides by these flimsy firetraps.

I wish to be understood in giving the above figures as making an estimate merely from what examinations I could of the buildings, but I am assured they are, in the main, correct, and ought to demonstrate to the public that the loss to the fireproof buildings is comparatively very light.

Brick Buildings with Sandstone Veneer, Leland Stanford, Jr., University.

By the State Board of Architects.

Thorough inspections and investigation have been made through the burnt district, and it has been found that safety is not a question of style of architecture, but quality of workmanship.

Cornices and arches need not be excluded from the new city. Where they are properly anchored and built they withstood the shock and fire both. It is the opinion of the Board that the city need not be without its picturesque cornices and decorations. The Call and Kohl buildings are proof enough that good work on decorations will insure them against destruction.

The pile foundation has been found to be the most substantial. In the earth's vibrations it rests as does a chip in the water. And the building rests securely upon it. Forty-five feet is advised as a safe depth for either pile or concrete foundations.

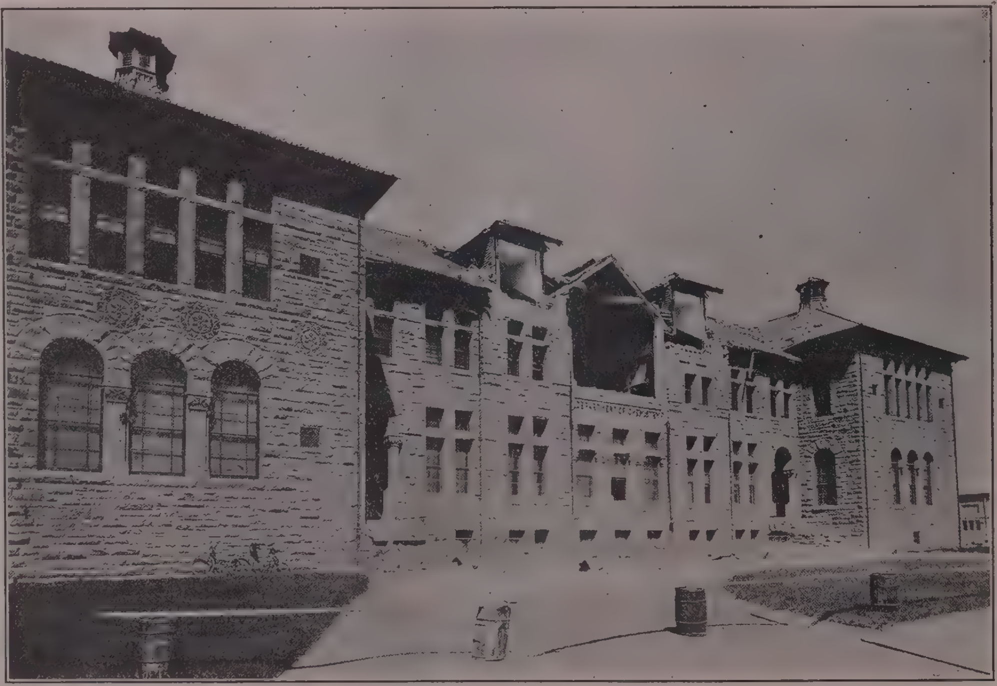
The height makes no difference in the matter of safety. Any building supported by what is known as the cage steel frame will withstand any ordinary shake. It is necessary that San Francisco have its high buildings. With proper workmanship they can be built in such a way that they will be absolutely safe.

Bay windows are not considered safe. And, though it is strongly urged that decorations be permitted, few projections should be allowed.

It is considered that the Ferry building sustained the most severe shock of any in San Francisco. Yet inspection shows that it is good for several more shakes such as the one of April 18. The tower is included in this statement.

By the Home Fire Insurance Co.

The chief adjuster of this company describes the burned area in San Francisco as follows: Beginning intersection Lombard and Bay Streets, south to Mission, west to Stuart, south to Howard, west to Main, south to Harrison, west to Beale, south to Bryant, west to First, south to Brannan, west to Second, south to Townsend, west to Eighth, north to Bryant, west to Eleventh, north to Fourteenth and Harrison. West on Fourteenth to Folsom, south to Fifteenth Street, west to Howard, south to Eighteenth, west to Mission, south to Twentieth, west to Dolores, north to Market, east to Gough, north to Foll, west to Octavia, north to Golden Gate, east to Van Ness, north to Sutter, west to Franklin, north to Clay, east to Van Ness, north to Greenwich, east to Hide, north to Chestnut, east to Jones, north to North Point, east to Bay, all buildings across street from above district partially damaged.



Chemistry Building, Leland Stanford, Jr., University, After the Earthquake.

By Prof. Frank Soulé, Dean, College of Civil Engineering, University of California.

I find, with the lapse of time, that my first report to you (see Eng. Record, May 12), is fully confirmed by further research and study of the results of the great earthquake; as for example by the report of the State Board of Architects (also printed on this page in somewhat condensed form).

All over the site of the city there are many fillings of made ground, some of sand and good earth from cuttings and gradings down of streets, and some of sand and rubbish fillings in the waters of the old former cove of San Francisco Harbor, and along the northerly shore and mud-flats of Mission Creek; in the latter case there have been extensive fillings of sand upon mud of unknown depth beneath. These last beds of foundation were the worst shaken and disturbed by the shock, and caused the greatest damages to their superstructures. The U. S. Post Office and the Valensia Hotel were upon beds of this kind. In case of sand or earth fill on good soil beneath, as in the instance of some of the well-built, wooden residences of the city, there was a disposition of the sand or earth to flow and let down the structure above it. This occurred to a great degree in several localities.

In general, throughout the earthquake region, the severest shakes and the greatest destruction wrought by them occurred in the valleys upon deep alluvial deposits; as at Salinas, Santa Rosa and Stanford University in Santa Clara Valley; the least harm being done upon mountainous, rocky ridges and soils above them, as in Berkeley, where the University buildings were unharmed, with the exception of one chimney, Sausalito and San Rafael near Mt. Tamalpais and even the high, rocky portions of San Francisco as compared with the low sandy levels. An exception of this rule exists in the cases of Bolinas, Tomales and other places along the mountainous sea-coast; but these localities seem to have been directly in the line of the great "fault" or "earthslip," running nearly north and south from Eureka for hundreds of miles along the coast to San Cruz and the Salinas Valley.

In Berkeley, near the Coast Range of mountains, the shock was lighter than in Oakland, five miles away upon the plain and flats of the harbor. Chimneys and plaster were the principal sufferers. New chimneys endured the shock better than old ones, as a rule; perhaps owing to the elasticity of the mortar, or to the old having been somewhat disintegrated by former shocks, or, in some instances, by the quality of the mortar, more cement mortar being used now than in former days. Tall house-chimneys, as a rule, stood better than short ones. High brick stacks usually broke at 20 or 30 ft. from the top, when foundations were good.

Practically no damage was done to the University buildings in Berkeley, or to its apparatus, but it lost by fire in San Francisco, the Hopkins Institute of Art, the Johnson building and some others; but the great Bancroft Library was saved both from 'quake and fire.

Hydraulic Features of the Plant of the Pike's Peak Hydro-Electric Co., Manitou, Colo.

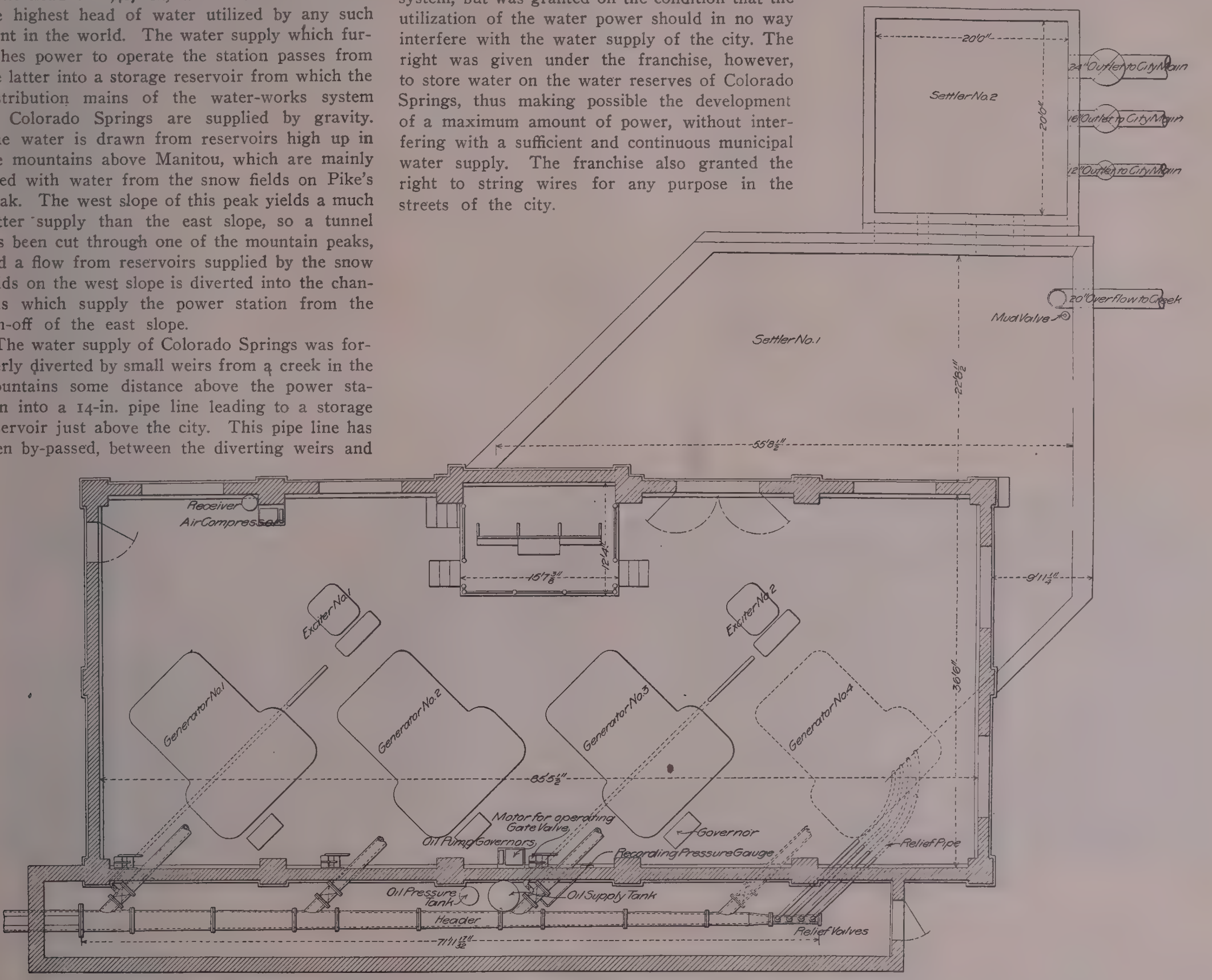
The generating station of the Pike's Peak Hydro-Electric Co., at Manitou, Colorado, is driven by water-power and operated under a static head of 2,417 ft., which is believed to be the highest head of water utilized by any such plant in the world. The water supply which furnishes power to operate the station passes from the latter into a storage reservoir from which the distribution mains of the water-works system of Colorado Springs are supplied by gravity. The water is drawn from reservoirs high up in the mountains above Manitou, which are mainly filled with water from the snow fields on Pike's Peak. The west slope of this peak yields a much better supply than the east slope, so a tunnel has been cut through one of the mountain peaks, and a flow from reservoirs supplied by the snow fields on the west slope is diverted into the channels which supply the power station from the run-off of the east slope.

The water supply of Colorado Springs was formerly diverted by small weirs from a creek in the mountains some distance above the power station into a 14-in. pipe line leading to a storage reservoir just above the city. This pipe line has been by-passed, between the diverting weirs and this storage reservoir, by a pipe line leading to the power station. The head that is now utilized by the hydro-electric station was formerly entirely wasted in friction in the 14-in. pipe line. The present plant has available an effective head of about 2,200 ft. of the total fall between the diverting weirs and the storage reservoir, the remainder being lost in pipe friction.

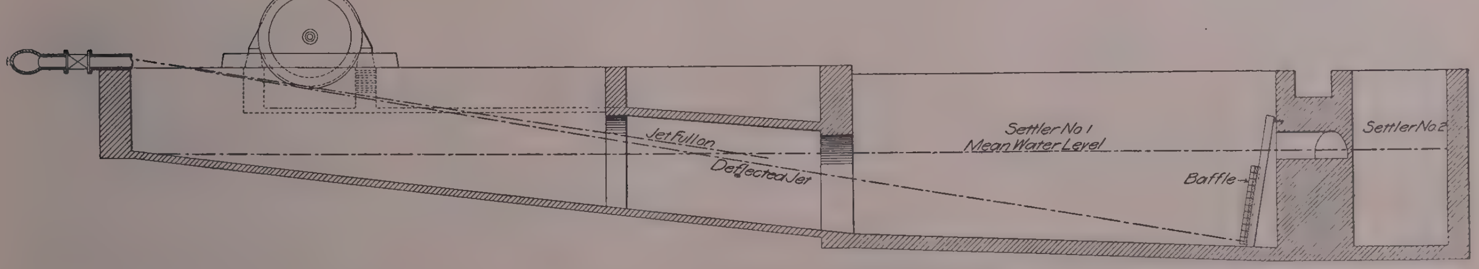
The station was built and is operated under a franchise granted to Mr. George W. Jackson, consulting engineer, of Chicago, by the city of Colorado Springs, in consideration for the completion of the tunnel which diverts the waters from the west slope of Pike's Peak into the streams supplied from the east slope of that peak. This franchise carried with it the exclusive use for 25 years of any water power that could be developed in connection with the water-supply system, but was granted on the condition that the utilization of the water power should in no way interfere with the water supply of the city. The right was given under the franchise, however, to store water on the water reserves of Colorado Springs, thus making possible the development of a maximum amount of power, without interfering with a sufficient and continuous municipal water supply. The franchise also granted the right to string wires for any purpose in the streets of the city.

The rights granted under this franchise were formally acquired on Jan. 1, 1903, by the Pike's Peak Hydro-Electric Co. Mr. G. A. Taff, president and general manager of that company, secured an option on these rights six months previous to the time they were acquired by his company and made a thorough preliminary investigation of the possibilities of the water power development. The minimum discharge through the 14-in. pipe line from the diverting weirs to the mountains to the storage reservoir above Colorado Springs was found to be 486 cu. ft. per second and the maximum discharge 1,111 cu. ft. The mountain reservoir sites could be developed to have an ultimate capacity of 336,900,000 cu. ft. The 14-in. pipe line leading to the storage reservoir above Colorado Springs was nearly all laid in a canyon up which a cog railroad leading to the top of Pike's Peak is built. This pipe line was not sufficiently strong for the head under which the power plant was to be operated. A new pipe line, the lower end of which would be able to withstand safely the pressure due to the 2,400-ft. head, had, therefore, to be built, and is the by-pass to the 14-in. pipe line.

A line of comparatively light weight pipe was laid along high ridges for some distance from the diverting weirs in the mountains toward



Plan of the Power Station of the Pike's Peak Hydro-Electric Company.



Section of the Power Station of the Pike's Peak Hydro-Electric Company, Showing the Path of the Jet.

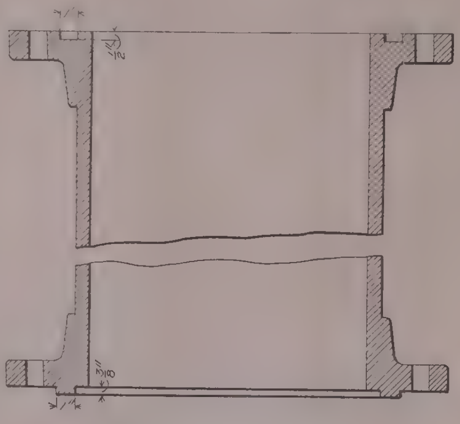
the power house. From the end of this lighter pipe an abrupt drop was made through a short length of pressure pipe leading to the station. The light pipe was laid with only sufficient grade to overcome the head lost by the friction of the water flowing in it. This pipe line is considered to be the most remarkable installation of its kind that has been completed. From the diverting weirs to the upper end of the pressure pipe, the pipe is 20 and 21 in. in diameter, and built of sheet steel, with single-riveted lap seams and riveted lap joints. It contains no curves of less than 20 ft radius. The pressure pipe is 4,775 ft. long and has an internal diameter of 21 in. This pipe is also built of sheet-steel plates, which decrease from a thickness of ¾ in. at the power house until the top of the steep incline is reached. The longitudinal joints on this pipe have double-butt straps, one inside and one outside of the pipe, with a triple row of rivets on each side of the joint. The pipe was built up in sections 32 ft. long, each section consisting of 5-ft. lengths, lap-jointed together. Special flanges were riveted on the ends of the 32-ft. sections and the joints between the latter made by bolting these flanges together.

The details of the flanges on each 32-ft. section of the pressure pipe are shown in an accompanying illustration. The face of the flange on one end has an annular counter-bored groove, ½ in. deep and 1 in. across. An annular lug 1 in. wide is turned on the other flange and projects ⅜ in. from the face of the latter. When two sections were joined together, the lug on the flange of one fitted into the counter-bored groove on the other. The counter-bored groove contains a gasket of an alloy composed of one part tin to one part lead. This gasket successfully withstands the pressure on the pipe line, although pure lead was squeezed out of the joint in a thin film when the pressure was applied. It is considered that the pure lead could have been used successfully if the lug and the counter-bored groove on each pair of flanges had been turned to accurate fit, instead of the loose, sliding fit that was used.

Hauling Low-Pressure Pipe.

Hauling High-Pressure Pipe.

The pipe was manufactured by the Holthoff Machinery Co., now the Power & Mining Machinery Co., of Cudahy, Wis. In manufacturing the pipe plates of sheet steel in 5-ft. lengths were rolled into the proper tubular form and the seams riveted on a 100-ton hydraulic press. This press had a special oil-tempered nickel-steel stake, 18 in. in diameter, over which a length of pipe would be placed for riveting. A very heavy footing had to be provided for this stake, but the latter would spring only slightly under the pressure brought against it while riveting near its top. After the seams of the 5-ft. lengths had been riveted and the joints between the latter in a 32-ft. section had been made, these joints had to be caulked under pressure, as in no other manner could it be determined whether they were tight. A factory test of 2,000 lb. per square inch was applied on all the pipe used in the lower end of the pressure pipe, double the working pressure being applied as a shop test to all of the pipe. The pipe was designed by Mr. Taff to have a factor of safety of three. The use of the tin and lead alloy for the gaskets in the flanged joints was suggested by Mr. F. M. Davis, superintendent of the factory of the Holthoff Machinery Co.



High-Pressure Pipe Joint.

Owing to the long, steep grade on which the pressure pipe is laid, the pipe for this portion of the line was brought to the position it was to occupy and laid under very unusual difficulties. A 30-in. gauge tramway was built from a railroad yard some distance below the power house up to a point near the latter and then up a steep incline along the location of the pipe line. Cars were hauled up this incline by a ¾-in. steel cable driven by an electric motor in a shed at the foot of the incline. The construction of the tram road on the incline was also carried on with considerable difficulty. The sides of the mountain are so steep in places along the pressure pipe that the workmen engaged in the construction could not stand along the side of the tram road without grasping something firmly anchored in place.

The pipe for the entire line was unloaded from a railroad siding at the foot of the tram road. The light-weight pipe for the low-pressure line along the high ridges was hauled up this tram road and thence to the top of the incline. This pipe was then rolled off the tram cars and loaded on a special four-wheel wagon, on which it was hauled by a horse along the grade that had been made for the pipe line. The pressure pipe was laid in a trench cut along the tram road on the incline. The car on which the pipe was hauled up the incline consisted of two four-wheel trucks, one under each end of the section of pipe. The forward truck carried 1,000 lb. ballast to overcome the lifting effect brought on it by the cable at changes in the grade of the tram road. The tail rope of the idler of the hoisting mechanism over which the cable operated carried a 3,000-lb. counterweight. This hoisting mechanism would draw a load of 15,000 lb. up a 62½ per cent. grade, although the heaviest load taken up was 12,000 lb., including the car.

In laying the pressure pipe, great precautions were taken to anchor it thoroughly. The trench was dug or blasted for the entire length of the line, and filled with concrete after the pipe was laid where the trench was made through rock. The pipe was laid without convex curves except near the top, so that it will not be forced out from the mountain side. Only one horizontal curve is included in the pressure pipe, and a heavy steel shoe braced against the rock prevents lateral movement at this curve.

The power house at the lower end of the pressure pipe is a one-story brick structure, 36.5x72 ft. in plan, on a concrete footing. Owing to the steepness of the side of the mountain a large excavation had to be made before the building could be constructed. Provision has been made in the power house for four alternating-current generators, each direct-connected to a Pelton water wheel. The pressure pipe ends in a heavy header along one side of the building, and a branch extends from this header to each of the water wheels. At the end of the header are four 2-in. Crosby relief valves adjusted to open at 1,100, 1,200, 1,300 and 1,400 lb. pressure, respectively.

The generators and water wheels are placed at an angle, in order to facilitate the disposition of the waste water from the nozzles of the water wheels. The stream of water that issues from one of these nozzles is under a pressure of over 940 lb. per square inch. Careful design was required to provide a proper water cushion to reduce the force of this stream before it impinges on wood or masonry structures. The speed of the water wheels is governed by deflecting the nozzles away from the buckets on the wheel when the load on the generator is light, thus allowing part of the water to pass the wheel and enter the tail race with full force. When the load is fluctuating considerably, almost the entire jet from a wheel may occasionally reach the tail race.

A concrete tail race is built under the machinery floor of the power house building, and is continued in a settling basin, 22 ft. 8 in. wide, at the side of the building. Beyond this settling basin is a second settling basin, separated from the first basin by a concrete wall, from which the water flows to the storage reservoir of the city water works. The bottom of the tail race is approximately parallel to the jet issuing from the water wheel, as may be seen in an accompanying cross-section through the tail race and settling basins. When the jet is fully deflected from a water wheel it strikes the water in the tail race and first settling basin at such an angle that it has a water cushion 40 ft. long and several feet deep before it reaches a cast-iron baffle against the wall between the first and second settling basins. The unthrottled jet will under no conditions reach the baffles. It ploughs deep furrows in the water cushion, which collapse when they reach a certain depth. This cycle of cutting and filling in the tail water is continuous.

Each baffle is cast in twelve sections, which slip over inclined I-beams. The face of a baffle has a double concave surface, with a projecting edge between the two concavities which will split the jet, should it ever reach the baffle, and the two concave surfaces will divert it back into the settling basin. The baffles are made in sections for convenience in handling and to avoid the necessity of removing an entire baffle if a part of it is worn out.

Three of the four 750-kw. General Electric generators and the water wheels to which they are direct-connected have been installed. Each of these units operates at 450 r.p.m. An efficiency test of these generators and water wheels was made by Mr. Taff, and Mr. George M. Peek, of the Pelton Water Wheel Co. The three wheels developed an efficiency during these tests of 61.50, 64.51 and 68.85 per cent., respectively, or an average on all three of a little less than 65 per cent. efficiency at normal full load.

Two Views along the Low-Pressure Pipe Line.

The Pelton wheels are governed entirely by deflecting the nozzles away from the wheel, since the high pressure under which the wheels operate preclude throttling the supply. The wheels are each also provided with a needle nozzle with which the size of the stream may be varied by hand. Two of the units are generally operated and the third held in reserve. Usually the needle valve of one wheel is adjusted so that its governor is inactive. This generator then works on a constant load, the fluctuations in load being taken care of by the governor on the other wheel. This arrangement has been found more satisfactory than to attempt to provide for fluctuations with both governors.

The unusually high head on the pressure pipe makes it imperative to have valves on the pipe line which close very slowly in order to avoid water hammer. The gate valve controlling the flow of water to each of the wheels is operated by an electric motor. The motor is worm-geared to the valve stem, the gear being thrown in and out by a handle on the hub of a large hand wheel. With this motor operating at full speed it requires 25 minutes to close the valve when the latter is completely open. The needle valves are also equipped with hand wheels which prevent them being closed rapidly.

Two 45-kw 125-volt exciter units, direct-connected to small Doble water wheels running at 975 r.p.m. are included in the station. The conditions being such as to make certain that the power house will never be extended to include more than the four generator units, the switchboard was built with a fixed number of generator and feeder wire panels. The board is mounted on a reinforced-concrete platform raised above the floor of the station, and is equipped with oil switches operated by compressed air.

The power generated in the station is at present sold to the Colorado Springs Electric Co., with the exception of the small amount used in lighting Manitou and the streets and public buildings in Colorado Springs. Two main feeder wires run from the station to a switching substation of the Colorado Springs Electric Co. This company has a steam-driven generating station located directly at coal mines in Colorado Springs. The equipment of this station is sufficiently economical to produce a kilowatt-hour of power with a consumption of 7 to 8 lb. of cheap, lignite coal. The company prefers, however, to purchase power from the hydro-electric station rather than to develop the power in its own station.

The pipe line and power station of Pike's Peak Hydro-Electric Co. were designed and constructed under the direction of Mr. Taff, and the station is operated under his supervision.

THE KNORRING-NADROWSKI TURBINE SYSTEM is a method of working steam turbines that has been developed at the Dresden Polytechnic Institute to introduce higher temperatures in the cycle than would be possible with piston engines and to recover as much of the rejected heat as possible in a regenerator. The steam is also reheated between the different pressure stages. The course of the steam in a two-stage turbine, for example, is from boiler to superheater, to first stage, to second superheat, to second stage, to regenerator, to feed-water heater, to condenser. An elaborate paper by Messrs. Nadrowski and Dahlke in the "Zeitschrift" of the Society of German Engineers, gives results of experiments indicating that great improvement in the heat utilization is possible when the temperature for the low-pressure stage is raised to 500° to 600° C., which the superheater is quite capable of carrying as the pressure is only about that of the atmosphere. A further saving is obtained by intermediate superheating again, if more than two stages are used. The paper is accompanied by elaborate tables and many diagrams from which the details of the test can be ascertained readily.

The Use of Producer Gas for Power Generation.

By Godfrey M. S. Tait.

To arrive at a less wasteful means for the utilization of the heating value of coal and similar fuels has long been the aim of practical engineers, and it is due to the remarkable economy shown by plants consisting of gas producers and gas engines over even the highest type of triple-expansion condensing steam plants of the same horse-power that most of our prominent engine builders have already taken up the manufacture of gas engines in large units. Unfortunately, while the economy derivable from the use of gas-producer-gas-engine installations is an admitted and accomplished fact, the reliability of this type of installation has not until very recently reached the point of a similar installation of steam.

In investigating the fundamental reasons for the unreliable service hitherto experienced with gas engines operating on producer gas, the writer found that all this trouble could be traced to the varying proportion of hydrogen in the gas supplied the engine, the hydrogen varying in accordance with the temperature of the fuel bed in the producer, which in turn, was controlled by the amount of load on the engine.

In order that the reader may fully appreciate the wide range of conditions under which a producer is called upon to operate attention is called to the following, which is a fairly average analysis of producer gas made under the usual method employing steam as the temperature reducer and gas "enricher": Carbon dioxide, 5.8 per cent.; oxygen, 0.3; carbon monoxide, 20.8; hydrogen, 15.1; marsh gas, 1.3; nitrogen, 56.7.

As will be seen from this analysis the active part of the gas consists practically of carbon monoxide and hydrogen, and the total heating value as determined by calorimeter will be found to be in the neighborhood of 136 B.t.u. per cubic foot.

Now, if it were possible to maintain this composition exactly as shown, uniform results could be obtained from the engine, but unfortunately as the temperature of the producer rises and falls, due to changes in the load of the engine, the percentage of steam, which dissociates to form hydrogen and carbon monoxide, also varies. In fact, so great is this variation that, for example, under full load the producer temperature in the dissociating zone will be about 2,000° F.; and, as at this temperature practically all the steam passed up through the fuel bed is converted into hydrogen and carbon monoxide, a very "rich" gas, high in hydrogen will result; whereas under low load the temperature of the same part of the fire drops down to about 1,300°

F., and only about 10 per cent. of the steam passing up through the fuel bed will be found to dissociate, the balance merely becoming superheated and passing off to the scrubber, carrying with it considerable heat in the form of superheated steam which is lost in the scrubber and produces thereby considerable waste.

From this it will be seen that the variable element in the producer gas is in its hydrogen constituent and that to this continually changing volume we can attribute the unreliable features of the gas-producer-engine system.

In addition to the loss of power incident to the decrease in richness of the gas supplied to the engine we find another trouble, which is indicated by loss of power when the gas is running richer than the average; for example, when the calorimeter shows 156 B.t.u., the engine is very apt to slack up and stop. This phenomenon led the writer to study out the action of a composite gas such as producer gas in an engine cylinder under varying conditions, and in the course of these investigations it developed that a composite gas was very undesirable for power purposes. In producer gas the main active constituents consist of carbon monoxide and hydrogen, but the rate of combustion of carbon monoxide in a gas engine cylinder is only about one-half that of hydrogen. From this is will follow that in order to obtain the full power from the hydrogen constituent it is necessary to have the ignition on the engine late enough to coincide with the burning period of the hydrogen. In doing so, however, it is obvious that the ignition is started too late to derive the full benefit of the power contained in the carbon monoxide, which is not fully burned under these conditions during the power stroke causing the heat units to be absorbed to a much greater extent by the jacket water instead of doing useful work.

This accounts in a very large measure for the fluctuations in power experienced with engines operating on producer gas; for, at low load when the producer is fairly cool the major part of the power contained in the gas will be found to consist of carbon monoxide, the fuel bed not being hot enough at that period to dissociate the steam to any extent. Under this condition the engine is called upon to operate on the carbon monoxide gas, and as the ignition has been set to coincide with the hydrogen, it is naturally so late that the power developed is all out of proportion to the amount of carbon monoxide present, being so slight in some cases as to cause the engine to shut down after a short run.

To go to the other extreme, after a producer has been operating continuously for several hours under full load the temperature of the fuel bed reaches the maximum point at which all the steam supplied is dissociated. This being the case where the gas may run up to 156 B.t.u., the engine under these conditions will again slack up, and we find that this is due, without exception, to premature firing caused by the rapid combustion of the hydrogen constituent in its now increased proportion, not being admixed as heretofore with the carbon monoxide of a slower burning tendency.

Having these facts in mind it would therefore seem reasonable to suppose that if a gas consisting of pure carbon monoxide or pure hydrogen were to be employed very much better results could be obtained.

Of course, it is impossible to generate free hydrogen commercially, and even were we able so to do, the violent impact given by this gas on account of its quick ignition would be very apt to injure the engine.

Our next step, therefore, would be to ascertain a means for generating a gas consisting essentially of carbon monoxide, and this we can do by merely admitting air to the fuel bed of the producer. However, in running a producer on a draft consisting of pure air the temperature of the fuel bed would rise so rapidly and to such an extent that in two or three hours under full load the whole mass of fuel in the producer would be reduced to a clinker, which would necessitate complete shut-down.

The next step then is to find some material which can be introduced along with the incoming air draft to the producer, which, having a retarding action on the temperature of the fire, will at the same time neither add to nor deduct from the carbon monoxide desired in the finished gas.

A suitable means of obtaining this result is now embodied in a process owned by the Combustion Utilities Co., which has had issued to it broad fundamental patents on the use of carbon dioxide for the regulation of flame and combustion temperatures in gas producers, furnaces, etc.

Referring to this means of operating a producer, the writer recently conducted a complete test on a gas-producer-engine plant which had been operating under the usual system of a draft supplied to the producer consisting of a mixture of steam and air. With this plant the writer first ran a complete test to demonstrate the maximum capacity, continuity of operation, and fuel consumption under the usual method of operation. Upon completion of these tests he had the plant equipped with the C. U. process, which consisted in this instance of tapping the exhaust from the engine for the purpose of obtaining the carbon dioxide therefrom, entering the carbon dioxide with the air supply to the producer, disconnecting and removing all steam generating or supplying devices hitherto used, and in the case of the engine, raising the compression to 200 lb., which is entirely admissible when operating under this system, which is due to the fact that in a gas containing no hydrogen there will be no danger of pre-ignition even at varying loads.

Efficiency of the Two Gas Systems and Ordinary Steam Plant of the Same Size.

		C. U. Co. process.	Ordinary system.	Non-cond'g. steam plant.
1. Brake horse-power		102.5	78.7	100.
2. Coal per B.h.p. per hour	lb.	1.12	1.8	3.6
3. B.t.u. supplied to plant per hour	B.t.u.	1,402,644.	1,733,800.	4,411,080.
4. B.t.u. supplied to plant per b.h.p. per hour	B.t.u.	13,396.	20,640.	44,111.
5. B.t.u. supplied to engine per hour	B.t.u.	1,028,712.	1,400,374.	3,273,400.
6. B.t.u. supplied to engine per b.h.p. per hour	B.t.u.	9,797.	16,667.	32,734.
7. B.t.u. converted into work per b.h.p. per hour		2,545.	2,545.	2,545.
8. Efficiency of whole plant (line 7 to line 4)	Per cent.	19.	12.3	5.7
9. Efficiency of producer (line 6 to line 4)	Per cent.	73.1	80.	74.
10. Efficiency of engine (line 7 to line 6)	Per cent.	25.9	15.3	7.9

Heat-Balance.

		C. U. process.	Ordinary system.
1. Total heat of combustion per lb. of dry coal by calorimeter	B.t.u.	12,253.	12,253.
2. Dry coal consumed per hour	lb.	114.8	141.5
3. B.t.u. supplied to plant per hour	B.t.u.	1,406,644.	1,733,800.
4. Heat rejected per hour by producer and pre-heater jacket water evaporation	B.t.u.	101,430.	0.
5. Heat rejected per hour by scrubber water	B.t.u.	145,124.	202,048.
6. Heat rejected per hour by cylinder jacket water	B.t.u.	342,719.	370,944.
7. Heat rejected by exhaust manifold jacket water	B.t.u.	63,966.	98,400.
8. Heat converted into work	B.t.u.	267,225.	213,780.
9. Heat lost by exhaust gases, assuming that with the C.U. process 20 per cent. of the heat is returned	B.t.u.	354,802.	459,756.
10. Heat unaccounted for	B.t.u.	131,378.	388,872.
Total		1,406,644.	1.733,800.

The results of this second test were highly satisfactory, the engine operating with a smoothness and continuity hitherto only obtained from a similar steam plant, while in addition the coal consumption was materially lessened, the attention to both producer and engine was very much less, and at all times and under all loads the gas composition remained practically constant.

The advantages derived from the application of the C. U. process to this plant were:

First: Owing to the cooling effect (chemical) of the carbon dioxide, admitted below the grate, the maximum temperature of the fire was reduced, with consequent absence of clinkers and saving of loss due to radiation and high sensible heat.

Second: The variations in temperature such as were produced between light and heavy load, while enough to affect the dissociation of steam, were not found to have any noticeable effect on the rate of conversion of carbon dioxide into carbon monoxide. Next, the composition of the resultant gas was found by analysis to remain practically constant.

Third: Owing to the abandonment of the use of steam in this plant considerable saving was made, as no loss of heat was experienced through superheated steam passing over from the producer to the scrubber in a preheated condition, and for this same reason the amount of water required by the scrubber was noticeably less.

Fourth: In this process the gas generated contains less than 1 per cent. of hydrogen, which allowed the smooth operation of the engine under 200 lb. compression, this increase in compression materially increasing the capacity and efficiency of the engine, while at the same time absolute freedom from pre-ignitions (due to hydrogen) and back firing (due to lean gas at any period) was experienced.

Fifth: As this gas contained practically but one active constituent (carbon monoxide) it allowed the ignition point of the engine to be set to conform exactly to the time of complete combustion of this gas, thereby avoiding all losses due to late or early ignitions.

Sixth: Owing to the complete uniformity of this gas, as demonstrated by frequent analyses under varying loads, absolute freedom from pre-ignitions and back firing was secured, thus in addition to securing a much more satisfactory run, tending to prolong the life of the engine, while at the same time giving a power service in every way as reliable as a similar steam installation.

Subsequent to this test similar tests were run by Mr. George H. Barrus on the same plant under the same conditions, and herewith is shown a copy of the heat balance and efficiency table as developed. Referring to the heat balance, line 4, it will be noted that 101,430 B.t.u. per hour were rejected due to the fact that when using the C. U. process no provision was made to utilize the heat supplied to the pre-heater or evaporator, as their use would have entailed the admittance of steam to the producer. To this loss is due the fact that the producer in this instance only shows 73.1 per cent. efficiency as compared to 80 per cent. as usually operated. However, as can readily be seen, if the producer has been specially designed to operate under this C. U. system, the pre-heater, etc., would have been so arranged that the air supply would have passed through them minus the steam, and in this latter case the efficiency of the producer under the two tests would, of course, have been alike, namely, 80 per cent., which would in turn have raised the total efficiency of the plant above the figures quoted.

One of the main points of interest in the use and application of this process for power generation is the great increase in efficiency in the engine, due to the fact that a gas containing only one active constituent will develop more power in a cylinder of given area than a gas consisting of two active constituents, even when the sum of them represent 50 per cent. higher B.t.u. The reason for this is, as explained above, the difference in rate of combustion of the various constituents, which renders it impossible to derive the total power from a mixed gas.

From the results obtained in this plant and elsewhere by the use of this new process, it would seem that the difficulties hitherto encountered in the steady and continuous operation of gas engines from gas producers at varying loads have now been altogether overcome and that there is now no reason why a gas producer-engine plant should not replace the steam plant for all ordinary service where reliability and continuity of operation is required.

Damage From Tunneling Near Buildings.

Tunneling near buildings in Seattle was claimed to have caused serious damage to them, by the plaintiffs in a case, 84 Pac. Rep. 18, recently before the Washington Supreme Court. The special facts of the case are hardly of interest, but the court made some general statements on the subject that are instructive. The court rules that "when soil is removed from its natural position by one owner and the soil of an adjoining owner is thereby permitted to fall, such result is not a consequent damage but a direct injury. It follows that the liability does not depend upon the degree of care or skill used to prevent damage." It was claimed by the owners of the tunnel that the buildings were injured, if at all, by tapping a quantity of ground water on the line of the work, and that this water carried the soil with it when drawn off; on this contention, the tunnel owners were not liable. On this point the Washington court quotes as an expression of its own opinion the following ruling of a Massachusetts court: "Whatever may be true of percolating waters, we think that the defendants had no right to take away the soil of the plaintiff in land which they had not taken under the statutes, and that it is immaterial that the soil was removed by means of pumps from the trench into which it had fallen by its own weight, or had been carried by percolating water. We are unable to distinguish the case from one where the soil falls in from the surface in consequence of an excavation in the adjoining land."

Concrete Pavements in Worcester.

A method of constructing all-concrete pavements and concrete foundations for brick, stone and other surfaces has been in use for some time in Worcester, Mass., with satisfactory results. The street is first excavated to the proper subgrade, which is rolled when needed. Broken stone is then spread to a depth depending on the amount of load to be carried, and compressed with a road roller until the voids are reduced as much as possible and the surface is even. It is then thoroughly filled with a thick grout, prepared as used. The resulting concrete is more dense than that generally employed for the foundations of pavements and its cost is very low.

When a cement wearing surface is desired, a thick grout of sand and cement is poured over the foundation and immediately filled with fine crushed stone and rolled. By this process all voids are filled and the surplus water is flushed to the surface. When the concrete has hardened the pavement has a smooth but gritty surface which gives a good footing for horses and does not allow the wheels of automobiles to skid in wet weather. The accompanying illustration shows the appearance of a street of this type laid more than a year ago. It is subject to heavy travel, but has not given any signs of wear.

The foundation was used on several streets in Worcester paved last year with granite blocks, and will be used for all such work done in the city this year. The methods employed in constructing it and also the concrete wearing surface were devised by Mr. Walter E. Hassam, superintendent of streets of Worcester, and the patents controlling it are the property of the Hassam Pavement Co., of that city, which has been formed to introduce the methods elsewhere.

Hassam Pavement on Salem Street, Worcester, after One Year of Wear.

The Power Transmission Line of the Niagara, Lockport & Ontario Power Co. is about 160 miles long, being the longest east of the Rocky Mountains. The power plant of the company is on the Canadian shore and was described in this journal in several articles printed in October, 1904. There are three 10,000-h.-p. generators now in operation and a fourth is being installed. The current is transmitted down the gorge of the river about four miles, where there is a 600-ft. span to the American bank. Nine cables, each having 19 strands of No. 5 wire, are used. From this point the line runs through Lockport, Medina, Rochester and many smaller places to Syracuse. It is understood that the current will be used by some of the steam roads now being electrified.

Tendencies in the Foundry Business.

A paper read before the American Foundrymen's Association by Dr. R. Moldenke, Watchung, N. J.

To one who is constantly brought into touch with the demands of the discriminating consumer of the foundry product on the one hand, and who also knows the limitations the foundryman is working under in producing these castings, on the other, there become manifest certain tendencies that it will be well to recognize in order to be prepared for the inevitable when it finally arrives. Apart from the revolution in the foundry from old-time customs, there is manifest to-day a tendency toward refinement in method little dreamed of by the most ardent iconoclasts of a decade ago.

Perhaps our peculiar situation in this country, where the foundry is engaged in pushing specialties to the limit, has enabled us to take the lead in many directions. On the other hand we must deplore the lack of interest in, or shall we say lack of time for, many things, which if properly followed up, would remedy many a difficulty with our cost accounts. For instance, the adapting of the molding machine for production in quantity. This is sometimes truly marvelous, yet how little is known of it outside of the shops where this development has taken place. Again, how little is done by the producers of coke and pig iron to bring the ordinary classes of these materials up to the standard of what we now term "fancy" articles.

The importance of a thorough knowledge of the materials entering the foundry is becoming more manifest daily, and I remember distinctly the adverse criticism a book on cast iron came in for at the time of its publication because it went into the production of coke and pig iron too extensively. To-day we see that it is good to know how these processes are carried out, as we can more easily trace the causes of loss and difficulty in the foundry; conditions not realized by the makers of these materials, as they are not using them daily in the difficult art of making castings of the highest quality for the lowest price. I might go further and say that the founder who is also thoroughly versed in the art of casting brass and bronze is more apt to be particular with the iron end of his concern, and can overcome occasional metallurgical puzzles more easily.

Perhaps the very first thing which strikes the European foundryman who is visiting our plants, is the great stress laid upon system and organization in our strictly modern establishments. Where the European founder, with his more varied work of smaller aggregate tonnage, casts his pieces one by one, and finishes each with the assembling following directly, we, with an eye to the finer economies, prefer to put through an order of anywhere from a dozen to thousands of pieces of a kind, finishing them up for stock, and stealing the parts required for the sales and promises. As the stock in warehouse gets below a certain minimum, another shop order goes in to fill up the gap. As a consequence the work is always produced at the cheapest rates possible.

Here we strike the first tendency in the foundry industry. The specialization of our shops. It goes without saying that our European friends—and be it remarked that for over 20 years a steady stream of the most intelligent, observing and highly trained men have been visiting our plants with the avowed purpose of learning how we do things—quickly note the advantages we derive from our remarkably efficient systems of shop and office organization, and are introducing this American tendency into their respective countries as fast as they can be absorbed there. The result is a world-wide tendency in the foundry industry, which will have to be reckoned with some day from a competitive standpoint.

From this general point of interest, we can now get down more to particulars. Let us examine the noticeable tendencies in the foundry on the molding floor, the melting department, the laboratory and the management, with the many problems this has to solve. Then the industries which supply materials for our work, and lastly the tendencies of the foundry industry as a whole.

If we take into consideration that specialty work means the production of the same casting in very large quantities, we can see why machine molding in its various phases is beginning to play such an important role. I have personally known single orders of 100,000 castings of some 30 lbs. each given with simply a blue print of the casting attached to the document. Many times the quantity has been 30,000 to 60,000, which meant that economical work could be done here if anywhere. Actually the figures at which these castings were carried out would be astonishing.

Apart from the use of molding machines to turn out these classes of castings cheaply, there is a noticeable tendency to economize shop room, and hence molds are piled as high as they can be conveniently poured, it may be objected that this method oftentimes produces more sprues per pound of casting than the old way, and that if trouble comes, a stack of molds will be ruined instead of only a single one. Yet this system has been found to pay wherever tried, and the getting of more tonnage for a given floor space is bound to spread. The idea, however, should be followed out to its logical end wherever work is made in sufficient quantity. This would seem to be the stacking up of the molds in fairly deep foundry pits, the iron being brought in large ladles by traveling crane, and poured from the bottom of the ladle. Suitable variations in the method can naturally be devised for given cases but the idea remains the same; to get the greatest tonnage for a given floor space, in order to save investment and cost of output.

Greater attention will ultimately be given the preparation of the molding sand. Our European brethren are far ahead of us in this respect, every foundry of importance grinding its sand to a given standard, then passing through mixers which incidentally fill the perfectly uniform material with maximum of air, thus cushioning the sand and keeping it as open as it may be. When a highly refractory molding sand is used, this treatment assists in turning out the smoothest kind of work. As our consumers are constantly harping on better looking work, this point might be considered more carefully by American foundrymen. Many sands are exceedingly uniform in their natural state, as for instance the well-known "Albany," the result being highly finished castings, where the best molding methods are employed. On the other hand, who does not recognize a "Pittsburg" casting, that is one made in the sand dug in the environments of the smoky city. Judicious sand treatment would go a great ways to remedy the difficulty even there, did the good people make the class of work current in the Eastern States. What great differences may exist in molding sand in the same heap may be seen in an exaggerated way where sand conveyors are in use. Here, unless special precautions are taken, the loamy particles in the sand may get together, leaving the silicious portions without a binder. The result is that copes drop out, scabs are formed, etc. No wonder that in the ordinary tempering of sand an art is involved which must be acquired before a man can rate himself proficient in this branch of the work. Hence the tendency to get away from imperfections in the make-up of the molding sand heaps, by mechanical grinding and mixing. This tendency has not struck our country very hard yet.

Attention may be called here to the fact that a very noticeable tendency is being manifested by the manufacturers of foundry facings and other supplies of a like order, to learn more of their own art. The foundry industry as a whole is bound to benefit by this, and we wish our facing brethren all imaginable success.

Before leaving this branch of our subject, we must not forget to mention the growing tendency to perform as many operations about the foundry as possible by mechanical means. We have now some excellent examples of what may be done in this way in our advanced foundries. Whether it be the mechanical charging of the cupola, the mold and sand conveyors, metal distribution, compressed-air attachments, yard cranes, and the like, the tendency is to be encouraged as much as possible, as wherever the manual labor of several men can be replaced by the brains of only one, conditions of management are much easier to meet. The investment may become higher, but competition can be better met, and as a general proposition the resources of the nation are employed to its greatest advantage.

Perhaps this is as good a place as any to mention the growing demand for foundry standards. Thus flasks, pattern work, and the molding methods depending upon the close co-operation of the pattern shop with the molding floor, are coming in for considerable attention. The makers of molding machines will be greatly benefited by this desired standardization of flasks, for the time has now gone by when a manufacturer would go out of his way to get the most impossible screw thread, in order that the repairs subsequently necessary would have to come to him. We shall undoubtedly see the day when all the designs of the drafting office of an industrial-establishment will go for revision to its foundry superintendent, in order to standardize the non-essential elements therein and create less labor in producing the castings.

In going through many a foundry where very large loam molds are made for stock work, one cannot help regretting the tearing down of much of the mold which might be left standing if the subject of "permanent molds" had been studied more carefully by the foundry foreman. The tendency to-day is to economize in every way possible, and very often here is a chance to begin.

We owe much to our high class custom pattern shops for the progress they have forced upon the pattern end of our industry. It is not so long ago that metal patterns were unheard of in many foundries. It seemed like a waste of good money to put more time and effort on a pattern that was required by the ordinary article we all have piled on our pattern shelves. However, this tendency is growing steadily, and many a shop to-day can boast of a set of metal cutting machines which remind one of a first class toolroom. This tendency is, however, closely interwoven with the specialization of the foundry, and where a first class man is in charge, the pattern storage soon becomes less of a graveyard for obsolete material.

Perhaps we can also note a marked tendency toward more substantial buildings. Wood is becoming dearer. Fires are more disastrous to the business than to the shop itself. Hence greater precautions to prevent shutting down when least able to stand it. Whether foundrymen are becoming richer, or are more progressive is hard to say, but the number of new buildings going up to replace worn out and tumble down shacks is very gratifying.

Turning now to the melting and the closely allied laboratory, we see that the strongest marked tendency of the day in the industry is the production of higher grade castings by the addition of steel scrap, or in other words the reduction of the total carbon in cast iron, making the crystalline structure more closely adherent, and hence the whole casting stronger. Here the skill of the melter is joined with that of the chemist, so that value is received from the higher priced stock charged into the cupola. The cupola process is being studied more carefully and experts in that line can produce results close to those of the air furnace, or open hearth. Considering that this is accomplished with fuel and metal in contact, and by a notoriously unsatisfactory melting method, which the cupola process undoubtedly is from the standpoint of the treatment the metal gets in it, the foundry industry is to be congratulated upon its ability to retain a strong hold on the making of castings, in the face of the hard knocks it is getting from the steel casting establishments.

This tendency toward better grades of metal is but in its infancy. The cupola, which is a cheap melter, will undoubtedly be improved with the view of getting better results from the steel scrap additions. The metal will be safeguarded more from burning, and the additions of the scrap will be systematized more, so that a given quantity will produce given results more regularly than is now the case.

The tendency above mentioned has somewhat retarded the introduction of air furnaces in general foundry practice. However, taking into consideration the demand for better irons, better coke, better melting methods, the specialist founder will soon tire of buying high class material, and spoiling it, or taking big chances in that direction. He will naturally revert to the air furnace as better able to give high class results from high class material, and the consumer will be glad to pay the difference.

Those who have taken the trouble to follow the silver and copper market will have noted that the high levels reached are not due to spasmodic fluctuation made by financial manipulation, but are the result of a real ability on the part of the civilized world to absorb these metals. We have the same thing in the iron market. The swing of the pendulum from the 21,000,000 mark will soon carry the consumption of the metal far into the thirty or forty millions and unless the country can produce this quantity steadily, the price is bound to rise sharply. Now, today we find few men in our line of work who are out for abnormally high prices for their product. We all wish for nothing better than a fair profit on base purchase prices, which are fair to furnace and coke dealers as well as to us. Hence the output of our establishments will be kept as much as possible within conservative price limits, and the quantity will be made to increase gradually. It may, however, be said that the resources of the country will not be able to respond quite as fast as the demands that the rapidly increasing population is making upon them, and hence we will never see the days of 1894 prices again. For which let us be thankful. All this means that with better prices, even if pig iron and coke hold well up, a more liberal tendency in the way of investment is bound to manifest itself, and everybody will be the gainer.

Whereas once the melting point of the various cast irons formed the one absorbing topic for articles and discussion, at present it is the elimination of sulphur in the cupola. This is a good sign, and even if one man finds that he cannot get the results of the other, and therefore we are at present quite at sea regarding a desirable method, yet it shows a tendency, and a good one.

With more light on this question, it is but a step to work on others and finally we may get down to a closer study of the burning effects manifested in cupola and air furnace practice, which I hold, are the most important by far of all the phenomena of the foundry melting processes, granted that the chemical composition is otherwise correct.

This leads us to the use of the ferro-alloys in the foundry to correct the evils we know, and others we have a vague apprehension of. To-day the use of ferro-manganese and of aluminum is quite extended, and is really a help in many instances. With the poor pig iron and especially the very poor coke the smaller founder is forced to put up with, the use of either of the above mentioned correctives is to be recommended. Unfortunately ferro-manganese is hardly powerful enough to do much good in the foundry, unless the mixture has a goodly proportion of steel in it. When this is the case it means a higher melting point, and with higher temperatures than ordinary cast iron is apt to be poured at, much of the oxidation is removed, and we avoid the pin holes, other weakening and unsightly effects which seem to be somewhat the rule at the present day. The real foundry alloy, however, is still to be discovered and made commercially, and the day cannot come too soon for this desideratum to be realized.

I look forward to great improvements in the making of producer gas. We hear of mysterious developments across the water, by which a more powerful heating agent is secured. How true the reports are we cannot say, but that work is being done in that direction is certain. It may mean a cheaper and more powerful fuel gas, and if so, it has a good place in the modern foundry, for whoever has worked with gas instead of coal, will stick to the former until the price soars out of sight. Just how this tendency will work itself out in the foundry it is hard to say. Whether it means the use of the open-hearth furnace in the big foundries, or the making of electricity with the gas engine in the smaller foundries for use in melting, time will determine, but it is well to keep this development before us, and to profit thereby.

This brings us to the consideration of another matter. The Canadian government is doing much to foster the development of electric smelting. The makers of the latest types of electric furnaces are constantly getting better efficiencies. Now with a cheap gas, in a gas engine, and for the making of very small castings in small quantity, there is no reason why the small steel, malleable, and even gray casting industry, not to speak of the brass and bronze contingent, should not melt their stock in the electric furnace. The higher price of the work sold will probably stand this. This tendency will bear watching. I have recently noticed a neat suggestion by Dr. Waldo along this line, where he proposes to make Bessemer steel rings or suitably shaped small ingots, these to be of the composition of the steel casting. Now by charging these small ingots into the electric furnace, one obtains a fluid steel of the proper composition to cast. I would suggest as an improvement that the ingots be pre-heated up to the highest point possible without injury to the metal; say just as the ingots for rails or structural steel are treated. This would leave for the more expensive electric current only the finishing heat necessary to melt and superheat to the point right for pouring.

The few remarks above will show our foundrymen that we are by no means through with the improvement of our processes, and were it possible to enlist an active encouragement on the part of the industry, many of these very direct problems could be attacked, and possibly solved.

Finally we come to the general problems of the foundry, in which there are also marked tendencies for a change. This will probably affect only the very large industries for the present and next generation, but what may come after is hard to say. Foremost stands the rapidly increasing use of direct metal. This is more marked across the water, but is bound to come here also. The big segments for the tunnel shields and linings should never have been made of remelted metal. However, this does not mean that it was advisable from the first to jump into a new method for such vast contracts. Here again we strike the importance of the use of steel scrap in gray iron castings, in order to reduce the total carbon. I would not advocate the use of direct metal just as it is, but to have the stream of metal from the blast furnace go into large heated mixers, which means greater, in fact more easily attained uniformity than is ever possible with the cupola. Now into this mixer there should be charged successively quantities of steel scrap which has been heated up to almost melting. This accomplishes a two-fold purpose. First it gives a reduction of total carbon without lowering the temperature of the metal in the mixer too seriously to be corrected at once by the heating method used as well as the comparatively large quantity of metal that should be in the mixer all the time. Now the first result is the making of a high-grade cast iron. This iron should be good enough for all the purposes the process could be used for, such as the making of pipe, tunnel segments, ingot molds, etc.

The second effect of the addition of the pre-heated steel scrap is that the problem of "kish" is done away with. This is the bugbear of the direct metal foundry, and in fact has retarded the introduction of direct metal for important work so much that at one time it was thought out of question to think of ever going back to this centuries old way of making castings.

What, then, will be the result of this tendency? It means that blast furnaces will be located wherever the raw materials not only are favorable, but where there is a good shipping point for pipe, possible car wheels, and not impossible malleable castings for car work. The furnace proposition will then become one of allied industries to give an outlet for the pig iron made which will fit these uses, and all the pig iron not of composition to go into the various mixers will be put upon the market.

While this seems visionary, it is nevertheless a fact that one very large combination is about to break ground for just such an establishment, and we may hear from direct metal pipe very soon. With our American enterprise, one hesitates to say just where those changes in method of production as well as administration will end, and it is even within the range of possibilities to find stoves made at a blast furnace once the molding machine has conquered the field that is before it in that line.

Being in fairly close touch with the scientific and administrative end of the foundry industry, I can say that most of these tendencies have been put up right against me in one way or another during the last few years, and I can safely say that with the need of betterments at hand, and this need no longer capable of being attended to by the old fashioned yet highly respected men on the foundry floor; it remains for the men at the very top of our great industrial establishments to solve the fine points in producing enormous quantities of high grade castings, and to make them cheap. These men are to be found in our foundrymen's associations, in our great engineering societies, and wherever the active individuals of our industry get together to discuss questions of practice. I venture to say that without our progressive institutions of this kind, the foundry industry would be what it still is in some of our large cities, where the pig iron salesman makes the mixture, and the ignorance of the customer makes the price.

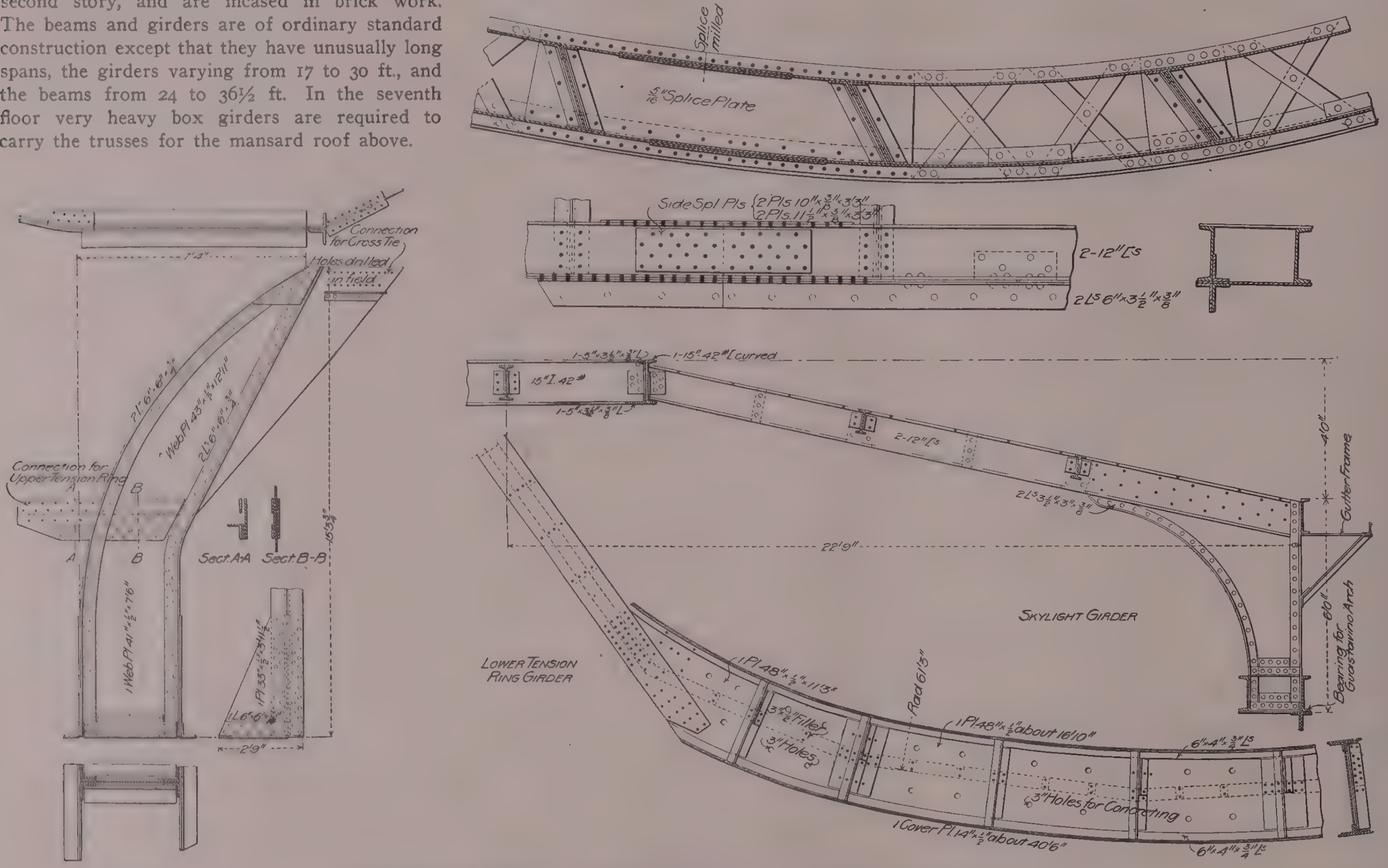
Court Decision on Water Rates.

Reasonable water rates were the subject of a voluminous decision of the New Jersey Chancery Court a few months ago. In its decision, 62 Atl. Rep. 474, the court ruled that a municipality, independent of statute, has power and owes a duty to protect its inhabitants against extortion in the price charged for water supplied by a private corportion furnishing water to it for public and private consumption, and to compel the corporation to furnish water at reasonable rates. It is a city's duty, however, to establish such rates as would enable the water company to derive a fair income, based on the fair value of its property at the time it is being used by the public, taking into account the cost of maintenance or depreciation, current operating expenses, and the right of the public to have no more exacted than the service in itself is reasonably worth, including a fair income to the stockholders on their investment. At the close of the decision the following remarks occur: "It is well nigh impossible to embody in a decree the rules and regulations and standard charges for the supply of water to a town, and it is quite impossible to so arrange them as to make the charges uniform, and at the same time distribute them equally among the different private consumers. Much must necessarily be left to negotiations in particular cases. Some towns allow the amount of frontage of an establishment to affect the charge, and this I think is right for reasons previously stated. Then there is the element of vacant lots, and then when a new street is opened and partly built upon the cost of laying the mains is precisely the same as if it were immediately closely built up, and that cost, of course, enters into the cost of supplying the pioneer builders on the street. These and other matters must be taken into consideration and dealt with in a spirit of accommodation and with a desire to treat all customers alike. The water company should at all times bear in mind that they are exercising a public franchise, which it is to use and not abuse. And the municipality must bear in mind that the stockholders of the water company are entitled to a fair income on their investment."

Electric Steel Refining is conducted on a large scale by J. Holtzer & Co., of Unieux, Loire, France, in producing metal for ordnance purposes. A 1,500-h.-p. steam-driven Westinghouse alternator furnishes a current of 20,000 amperes to a Keller furnace. The current is used only for the finishing refining action; the steel produced in an open-hearth furnace is run into the electric furnace immediately after the oxidizing melt, where the remaining operations are completed by the current. About 800 kg. of metal can be operated on at one time, and the operation can be repeated three or four times in 24 hours.

Some Structural Features of the New Custom House at New York.

The new United States Custom House, at Bowling Green, New York, occupies a conspicuous position at the foot of Broadway which demanded unusual care in the preparation of a dignified and beautiful design. The building is trapezoidal in plan with extreme dimensions of about 269 x 290 ft., and is about 140 ft. in height, with seven stories above the street level and two below it. The thick exterior walls are self-supporting and carry adjacent floor and roof loads. The hollow tile floors and roofs are made with arches about 5 to 6 ft. span, supported by a steel framework weighing in all about 6,800 tons. The columns have closed rectangular cross-sections made with pairs of channels and cover plates, field spliced every second story, and are incased in brick work. The beams and girders are of ordinary standard construction except that they have unusually long spans, the girders varying from 17 to 30 ft., and the beams from 24 to 36½ ft. In the seventh floor very heavy box girders are required to carry the trusses for the mansard roof above.



Principal Members in Steel Framework for Dome and Skylight.

An interesting structural feature is the great dome and skylight springing from the second floor level to cover the inner court. The plan is an ellipse with a major axis of 132 ft. 8 in. and a minor axis of 80 ft. 5 in. for the intrados. The corresponding vertical sections are elliptical curves with a rise equal to the semi-minor axis of the plan. The dome, however, is not complete, but terminates at a horizontal plane 21 ft. above the springing line, where it is surmounted by a 100-ton steel skylight having vertical walls about 4 ft. in height. It also has an elliptical plan with major and minor axes about 77 ft. and 45½ ft. long respectively. The surface of the skylight is pitched on straight lines from the eaves to the center, where there is an elliptical lantern 13½ ft. long and 8 ft. wide.

The segmental main dome is of Guastavino construction, with a double shell having the outer and inner surfaces made with the characteristic flat tiles of this system, laid in Portland cement mortar and connected by radial ribs 25 in. apart on centers, with diaphragms transverse to them. The outer and inner shells are thickened at the base so as to eliminate the hollow space at a point about 5 ft. above the skewback.

The dome is penetrated at both ends by vaulted ceilings, and near the center of each side it is intersected by transverse roofs which, however, do not penetrate it. The interruption to the lower portion of the dome introduced serious structural difficulties which were met by the special members and details here illustrated.

The dome was divided by radial vertical planes into short sections the weight and stress in which were computed to give the line of pressure and the reaction for the whole structure. From these it was determined that the line of pressure, owing to the heavy superimposed skylight, pierced the outer shell above the base of the dome and at this point a secondary horizontal tension ring was built between the outer and inner shells bedded in the masonry which is solid at this point. This second tension ring is composed of a 10x1-in. vertical plate riveted to 6x4x11/16-in. angle.

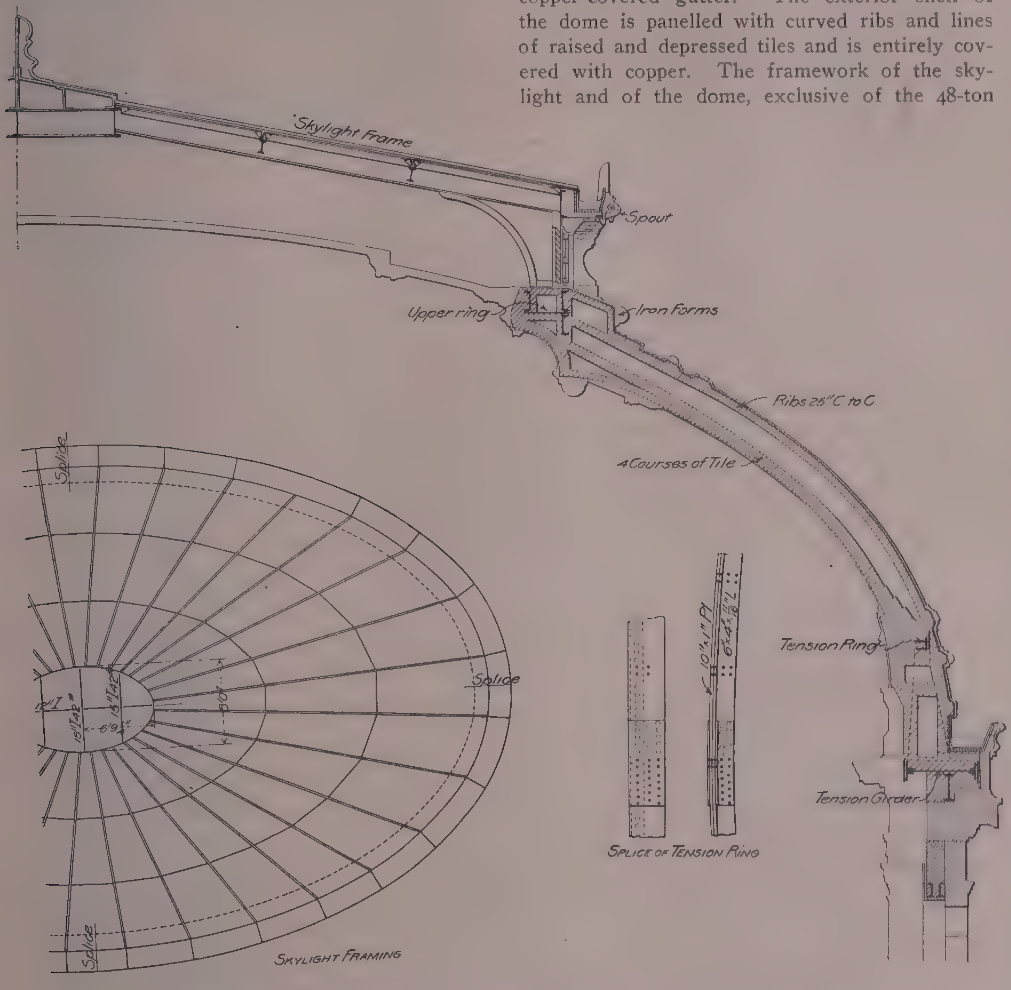
The base of the dome is seated on a horizontal plate girder with a 48½-in. web, two 6x4x¾-in. angles and one 14x½-in. cover plate in each flange. The girder is proportioned to resist the full amount of thrust computed for the dome considered as a voussoir arch, and the bending stresses due to unequal loading of the dome. It sustains the full weight of the dome and skylight and is supported at intervals on the top flanges of 15-in. I-beams which afford bearing to the web. The I-beams are riveted to vertical columns on the center line of the girder and form chords of the elliptical arch between them. Curtain walls are built between the columns to the under side of the girder, and the space between the girder and the top of these walls is filled with concrete deposited through numerous 3-in. holes left for that purpose in the web of the girder.

Owing to the penetrations at both ends of the dome the girder was interrupted at these points, thus forming only two long segments of an ellipse, the connecting end segments of which are missing. In place of these, however, it was possible to connect the ends of the girders across the penetrations by narrow horizontal tension members hidden in transom bars and riveted to the girders transverse to the major axis of the ellipse, thus providing for the balanced reaction of thrusts. The girder has a total weight of 48 tons and was shipped to the site in eight main pieces and four connection plates. The sections of the girder were about 42½ ft. long, and were spliced with double field-riveted plates and angle covers. Radial web stiffener angles and fillers were provided at intervals of about 4 ft. and the vertical flanges of these angles served as jaws between which were field-riveted, vertical connection plates serving to sustain temporarily the second tension ring until it was permanently supported by the dome masonry.

The second tension ring intersects the penetrations of the ends of the dome in a position where it is impossible to provide continuations to connect the ends of the intercepted segments in the same horizontal plane. In order to transmit the stress from one segment to the other at these points, provision was made for carrying them through a vertical offset to points above and below the plane of the ring, where the construction of the building permits the opening. This offsetting of the stresses developed very heavy moments, which are provided for by peculiar massive girders in vertical planes at the ends of the tension ring segments, transverse to the major axis of the ellipse.

These girders were constructed as shown in an accompanying drawing, and were made with a curved top flange corresponding to the outline of the roof which intersects the dome. The inner flange was bent to allow for the vaulted penetration. A horizontal projection of double-web reinforcement plates about 7 ft. above the base of the dome provides connection for the end of the upper tension ring segment and transfers the stress in it to the girder and thence to the foot where it is riveted to the main girder at the base of the dome, and to the upper end where it is riveted to a horizontal transverse member passing above the penetration of the dome, and connecting with the corresponding girder on the opposite side.

The bent girder is thus secured at both extremities, and the stress is divided so as to go both upwards and downwards from the end of the tension ring girder. This construction manifestly fails to provide balanced reactions and subjects the vertical curved girder to a very strong twisting stress, which is resisted at the foot by a pair of longitudinal gusset plates riveted to the flanges of the lower girders and by the backing afforded by the shell of the dome, which terminates at this point and is built solid against the web of the girder to afford resistance to its distortion.



Transverse Half Section of Dome and Half Plan of Skylight.

Ring 3 of the dome is a complete ellipse forming a drum to receive the thrust of the upper edges of the dome shell and support the skylight framing. It is made of two 12-in., 25-lb. channels having their vertical webs spaced about 18 in. apart and connected by top and bottom flange plates. A pair of 6x3½-in. angles back to back form a T-shaped extension riveted to the bottom flange of the outer angle to afford wider bearing for the top of the dome. The channels, forming a drum, were shipped separately in lengths of about 24½ ft. and were field-riveted together with flange and double web splice plates. The inner and outer channels are connected at 32 equi-distant points by vertical plates perpendicular to their webs, which are about 6 ft. high and form the webs of knee-brace supports for the rafters, as indicated in the semi-cross-section of the skylight on the minor axis of the ellipse.

The skylight rafters are pairs of straight 12-in. channels filed-riveted together back to back on the opposite sides of the kneebrace plates. Their upper ends are web-connected to a 13½x8-ft. elliptical drum made with a curved 15-in. channel reinforced by a 5x3½-in. angle on the top and bottom edge. The rafters are connected by two equi-distant concentric ellipses each formed of straight lengths of 8-in. I-beams web-connected to them with their top flanges flush. The panels thus formed are fitted with cast-iron frames, glazed, and are covered outside with copper. The lower ends of the rafters abut against a 12-in. fascia channel which, together with an outer 4x3-in. angle ring knee-braced to the vertical supports, forms the framework for the copper-covered gutter. The exterior shell of the dome is panelled with curved ribs and lines of raised and depressed tiles and is entirely covered with copper. The framework of the skylight and of the dome, exclusive of the 48-ton lower ring and the 30-ton second ring, contains about 57 tons of structural steel and 40 tons of cast iron.

The steel work in the Custom House was erected with two stiff-leg and one guyed derrick, each of a capacity of 15 tons, besides which there were used two jinniwink derricks for handling small pieces and two boom derricks for unloading and for other purposes. The three large derricks were served by Mundy hoisting engines, each with a separate boiler. Two of the engines were permanently located in the basement and one was moved from place to place on the fifth story. Each boiler was detached from the engine bed and kept stationary, the steam being delivered through screwed piping to within about 15 ft. of the engine to which it was connected by flexible hose. All field riveting was done by two Chicago pneumatic hammers and two Shaw pneumatic hammers operated by a Chicago air compressor driven by a General Electric motor with an automatic equipment made by the Automatic Switch Co., New York, and adjusted to start the engine when the receiver pressure fell to 85 lb., and to stop it when the pressure arose to 110 lb.

The erection of the floors was slow on account of the necessity of waiting for the masonry to be completed before the beams and girders could be seated on the wall bearings. The erection of the dome framework was very difficult and required great patience and skill to accomplish it accurately and secure the correct position of the irregular and unbraced framework, so that the dome could be built on true lines and would develop approximately the theoretical stresses. The columns on which the lower dome girder is supported were erected and enclosed in solid brickwork to within 15 in. of the top, where the elliptical girder was seated. The position of the girder seats were then checked, and it was found that all of them were more or less displaced, making it necessary to reframe all of the connecting beams. This required a large amount of fitting and drilling, and when accomplished resulted in the relative movement of the holes provided in them for connections to the elliptical girder so that none of them matched. Some of the beams had indeed been reversed so that the lower flanges came upwards and presented a surface in which new holes could be made without intersecting old holes.

The designing engineer had foreseen the difficulty of making shop holes come fair in the field and had expressly directed that these holes in the girder should be drilled in the field. This requirement was disregarded and all of them were punched in the shop. As none of them matched the holes in the beams great difficulty was encountered in drilling new holes and some of the flange angles were replaced by new ones on this account. Part of the holes were drilled by hand and part of them by pneumatic drills. Before the elliptical girder sections were riveted to the columns a precise survey was made by Mr. John G. Van Horne, which showed that the ends were in the required position, but that there was a maximum displacement of 3 in. on the sides. To correct this before drilling the holes the girder was adjusted to the required position by means of tackles, braces and screw rods, by which it was sprung at different points and forced to conform to the theoretical center line where it was maintained until the holes were drilled and the rivets driven, securing it permanently in that position.

After the completion of the lower girder the vertical brackets were assembled to it within 1/16 in. of the nominal positions, and the second tension ring was erected on them in quarter sections and securely bolted. The bracket connections to the lower girders were then loosened and the second tension ring was adjusted by turn-buckles and guys until it conformed exactly to six points on the low girder, determined by the survey and plumbed up. The brackets were clamped in this position, new holes were drilled, and the connections were riveted completely. The third girder or drum at the top of the section was assembled on falsework, which also supported the upper fascia ring and the small elliptical drum at the apex which was carefully centered. The skylight ribs were put in successively from the minor to the major axis, after which the cross beams were assembled to them and adjusted to points plumbed up from the axis and laid off on the second floor. When the position was thus accurately adjusted the connections were riveted up and the framework was securely held by eight guys until the Guastavino construction was completed, filling in the elliptical surface solid and completing the rigid structure.

About 75,000 field rivets were driven on this work and although the inspection was very rigid less than 0.2 per cent. of them were condemned and only a very few were cut out after the first three days.

The building was designed and constructed under the Tarsney act, the competition being won by Mr. Cass Gilbert, New York, who was therefore appointed the architect. Mr. Gunvald Aus was the consulting engineer who designed the steel work above described. Mr. Isaac A. Hopper was the contractor for the foundations and the wall and structural steel up to the first floor level. Mr. John Peirce was the general contractor, Mr. Emil Diebitsch being his general manager. The Hecla Iron Works furnished and set the steel up to and including the first floor. The American Bridge Co. furnished and set the second floor and the Brown-Ketcham Iron Works, Indianapolis, Ind., built the remainder of the steel work, which was erected for them by Mr. Henry Johnston, superintendent.

Brake Tests of a 500-Kw. Westinghouse-Parsons Turbine.

It is not often that brake tests of steam turbines are made and for this reason some runs of this character, made by Ludwig & Co., of Atlanta, on a 500-kw. turbine at the works of the Westinghouse Machine Co. are of special interest. The turbine will be used to drive a 500-kw. polyphase generator which was tested separately. It was designed to develop normally 750 b.h.p. with steam at 175 lb. at the throttle, 150° Fahr. superheat, 28 in. absolute vacuum and a speed of 3,600 r.p.m.

The turbine was subjected to different loads by a water absorption brake, operating upon the same principle as the Prony brake. The results were computed in like manner. During saturated steam tests approximately dry steam was insured at the turbine by slightly superheating the steam leaving the boilers. Its quality was determined by a throttling calorimeter in the usual manner. No corrections for moisture were made in the economy tests on account of the very small amount of moisture present. The steam used by the turbine was passed into a surface condenser and the condensation weighed by the alternate tank method, proper corrections being afterward applied. Condenser leakage was averaged from tests made before and after the economy tests. Gland leakage was likewise separately determined; also differences in the height of the water in the hot well of the condenser before and after the test were allowed for. All instruments used during tests, such as scales, pressure gaugs, mercury columns and thermometers, were carefully calibrated with standards to insure accuracy. Observations of steam pressures and temperatures were made close to the turbine throttle; the vacuum was measured directly at the turbine exhaust. Speed was determined by a positively driven reciprocating speed counter. All steam pressures referred to are gauge pressures, not absolute.

The complete results obtained under different conditions are summarized in the accompanying curve sheet. The results were obtained with 25 lb. less steam pressure and 45° lower superheat than called for in the contract, yet the guarantees were bettered by 4 to 6 per cent. with saturated steam and 3 per cent. with superheated steam. Applying the proper correction to the superheat test, the steam consumption under 150° superheat would have been 1.7 lbs. per b.h.p. hour, or nearly 8 per cent. better than the guarantee.

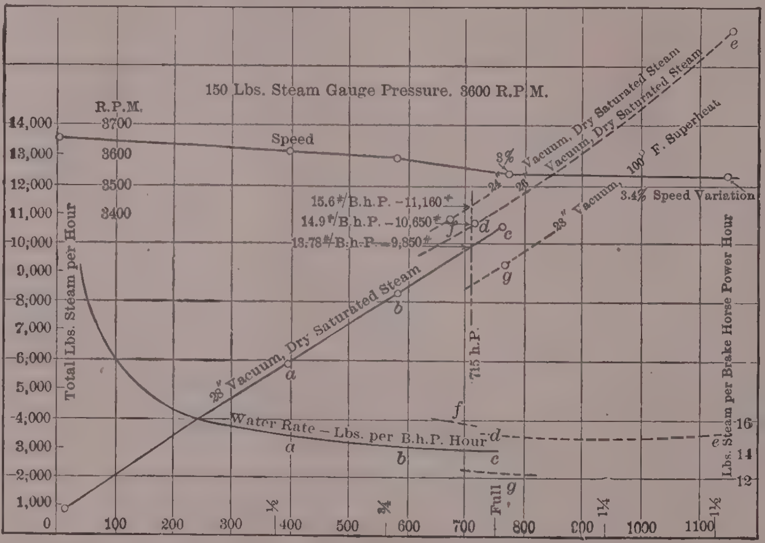
A comparison of the tests shows that the steam consumption decreases 1.46 lb. per brake horse power, with 105.2° superheat. This corresponds to about 10.2 per cent. decrease per 100°. It will, however, be observed that the vacuum in one test was 0.3 in. low, and for accurate results it is necessary to correct for this vacuum. Numerous tests have shown that the steam consumption of Westinghouse-Parsons steam turbines changes from 3½ to 4 per cent. per 1-in. vacuum. The decrease in steam consumption then works out about 9.2 per cent. per 100°. Applying this correction in turn to the water rate obtained with superheated steam, it appears that under the conditions for which the turbine was designed, namely, 150° superheat, the water rate would have been 4.1 per cent. lower than observed, i. e., 11.7 lb. per brake horse-power-hour.

The general effect of increasing vacuum is to lower the steam consumption more rapidly as higher vacua are reached. Conversely, with vacuum below normal the steam consumption will increase less rapidly as the vacuum falls. Three of the tests furnish the following results:

Load B.H.P.	Vacuum Absolute.	Steam Consumption Actual.	Steam Consumption at 715 B.H.P.
762	27.70 in.	13.68 lb.	13.78 lb.
723	26.03	14.91	14.90
679	24.10	15.86	15.60

Total decrease in vacuum, 3.6 in.
Increase in water rate, 1.82 lb.

On account of the different loads carried during the several tests it is necessary to reduce the water rates to the same basis, namely, to a given load, which has been done in the last column for approximately full load. This may be done graphically as shown on the curve sheet. From these results we obtain: Total increase in water rate per 1 in. decrease in vacuum, 3.67 per cent. of original water rate; 4.87 per cent. with 27.7 to 26-in. vacuum, and 2.44 per cent. with 26.0 to 24.1-in. vacuum. These results indicate the desirability of high vacuum; also, should the vacuum fall considerably for any reason the result would not affect the economy relatively as much as for a small decrease.



Curve Sheet Showing Results of Tests of 500-kw. Steam Turbine.

In the no-load test with 159 lb. steam pressure and 27.99-in. vacuum, the steam consumption was 712 lb. per hour and the load was 5.8 lb., caused by the friction and windage in the water absorption brake. This steam consumption represents the amount required to overcome the internal losses, and a comparison of this test with the full load test shows that this no-load steam consumption amounts to 7 per cent. of the full load steam consumption with saturated steam. Assuming that these losses remain constant up to full load, the practical efficiency of the turbine will be 93 per cent., and the steam consumption per indicated horse-power will then be 12.7 lb. per horse-power of saturated steam and 10.75 lb. with 150° superheat, these figures being mainly of comparative interest.

The speeds during the test were as follows: no load, 3,663.7 r.p.m.; half load, 3,623.3; three-quarter load, 3,604.4; full load, 3,555.3; 50 per cent. overload, 3,539. The slight change in curvature at about full load corresponds to the point at which the secondary valve commences to open. The corresponding extreme speed variations were therefore as follows: ½ load to 1½ overload, 84.3 r.p.m., or 2.3 per cent.; no load to full load, 108.4 r.p.m., or 3 per cent.; no load to 1½ overload, 124.7 r.p.m., or 3.4 per cent.

Repeated tests with full load suddenly thrown off and on gave the following results: From no-load to full load, 3 per cent. variation; from full load to no load, 2.6 per cent.

A special test was made on the performance of the automatic safety stop with which the turbine is equipped, to prevent its running away in the event of any accident to the governor mechanism. The stop was designed to instantly cut off steam should the speed from any cause rise above a predetermined limit. This mechanism was brought into action by holding down the governor by hand until the speed rose sufficiently to trip the valve. During the test the safety stop operated at 3,780 r.p.m., corresponding to about 5 per cent. above the normal running speed of the turbine.

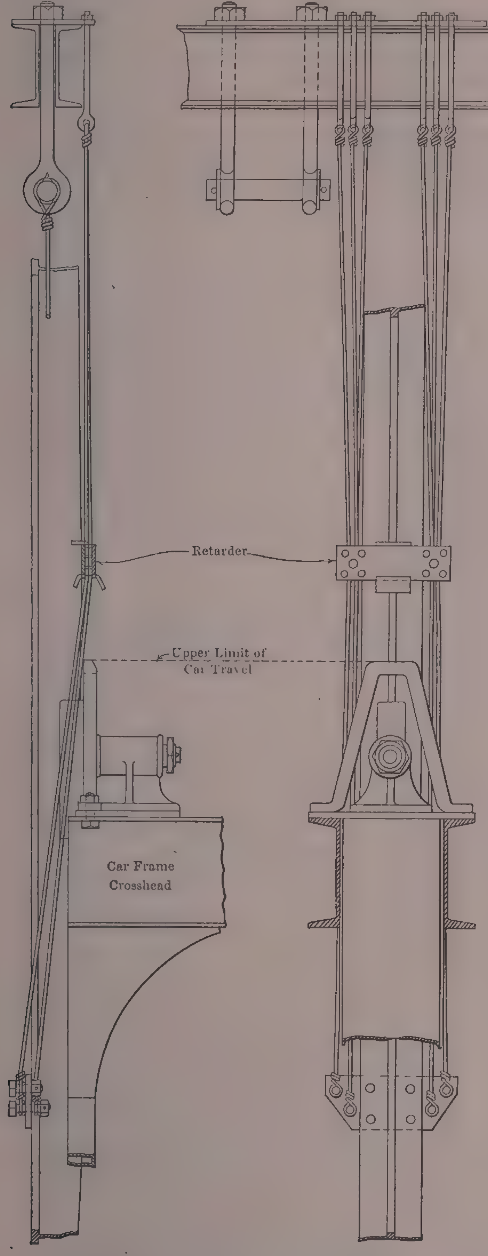
The turbine was designed to sustain a continuous load of 50 per cent. above full-load rating. A test was made at this load, and at 26 instead of 28-in. vacuum. The turbine easily sustained this for one hour at an overload of over 50 per cent., with an increase in steam consumption of but 0.17 per b.h.p.-hour, which is equivalent to but 1½ per cent. increase above the full-load steam consumption. The speed curve shows that through the assistance of the automatic secondary valve the limit of capacity of turbine even at low vacuum is considerably in excess of the 50 per cent. overload carried on test.

These tests also indicate that under practical conditions of service, where the vacuum is liable to fall from 28 to 26 in. on overloads, the steam consumption of the turbine between one-half load and 50 per cent overload varied by only 4½ per cent. from the average. With a uniform degree of superheat the variation would presumably be still less.

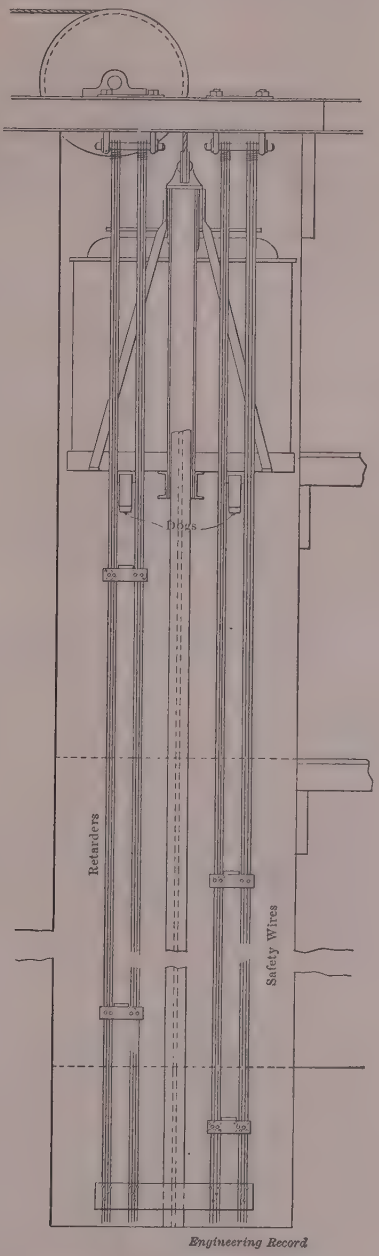
Reinforced Concrete Poles to the number of about a hundred are used on the transmission line along the Welland Canal in Canada. They are employed only where the wires must be carried at extra heights, cedar poles being used elsewhere. The first attempts to use reinforced concrete poles were unsuccessful, but the present design is giving satisfaction, owing to the details of the reinforcement.

Elevator Safeties at the Hotel Belmont.

The elevator equipment of the new Hotel Belmont in New York, described in The Engineering Record of Jan. 20, 1906, consists of nine elevators having travels of 285 to 323 ft. and a number of short-rise auxiliary machines. Owing to the distances and speeds at which the high-rise machines operate, particular attention was given to the safety provisions, and a new automatic safety mechanism has been applied to them. These machines are designed to carry loads of 2,500 to 3,000 lb. each and have maximum speeds of 500 ft. per minute, which necessitates protection from over-running at either end of the travel as well as from over-speed and cable breakage.



Details of Top Limit Stop.



Arrangement of Safety Wires.

The Cruickshank safety, which is the mechanism employed, differs from former devices in that it does not merely clamp upon the elevator guides while stopping a car, or make use of any form of grip or catch, operative only in case of danger, but is designed to be always in motion when the car is moving and operates so that only when the car is working in perfect order, will it be prevented from catching upon emergency stops; thus should either the elevators or safeties become disarranged, the fact will be made known at once. The device consists essentially of a series of steel wires suspended rigidly upon either side of every elevator shaft upon which are clamped stops known as retarders, and movable dogs on the edges of the cars which will normally engage the retarders in case of too rapid descent of the car or disordered mechanism. The retarders are spaced at regular intervals and the dogs are given, by means of a standing rope mechanism, a reciprocating motion which is so timed that they are drawn in so as to prevent their catching upon the retarders only when passing the latter, the action of the dog mechanism being such that if the car should begin to descend at a speed of from 100 to 200 ft. per minute in excess of the maximum operating speed, the dogs will, due to their weight, lag on the inward motion and catch upon the retarders. The effect of a pair of dogs catching upon retarders is to offer a constant resistance to the downward motion of the car which is a definite predetermined quantity depending upon the number of retarders, the number of wires upon which they slide and the form of the retarder itself. The retarder used is so formed as to kink the wires to which they are attached slightly so that in reality the resistance offered by them to movement is due rather to the fibre resistance of a constant bending of the wires than to mere slippage.

The accompanying drawings illustrate the arrangement of the vertical steel wires, the method of supporting them and the arrangement of the retarders. In each of the elevator shafts there are 32 wires suspended, in four groups of eight each, each of which wires is 0.192 in. in diameter and has a breaking strain of 1,800 lb. Each group of eight wires has retarders attached at spacings of approximately 24 ft., there being sets of retarders at or near every floor level on alternate pairs of eight-wire groups, so that a car would in no case have to drop more than about 12 ft. before catching upon a pair of retarders. These wires are secured at the top of the elevator shaft near the top fastenings of the guide posts to the sheave-supporting beams by short 2-in. steel rods suspended horizontally below the beams by heavy eye-bolts, around which rods the wires are given a double turn and spliced. This fastening is designed for uniform loadings and not for impact, it having been found that this form of safety does not bring sudden shock upon the elevator structure as in the case of a positive lock or latch. The retarders offer definite resistance in sliding upon the safety wires, whether fast or slow, and the total loadings due to these resistances are provided for instead of the enormously heavier construction that would otherwise be necessary for impact. The wires are fastened at the bottom merely by a binding clamp, by means of which they are kept rigid and from which they may be tightened if they become slack. To prevent swaying in the shaft, they are stayed by guide brackets mounted at frequent intervals upon the elevator guide posts, usually at points slightly above the retarder positions, to which they are lightly clamped by single binding wires of light gauge which will in no way interfere with the operation of the retarders in sliding with a dropping car, but are effective in holding them from vibration or swaying.

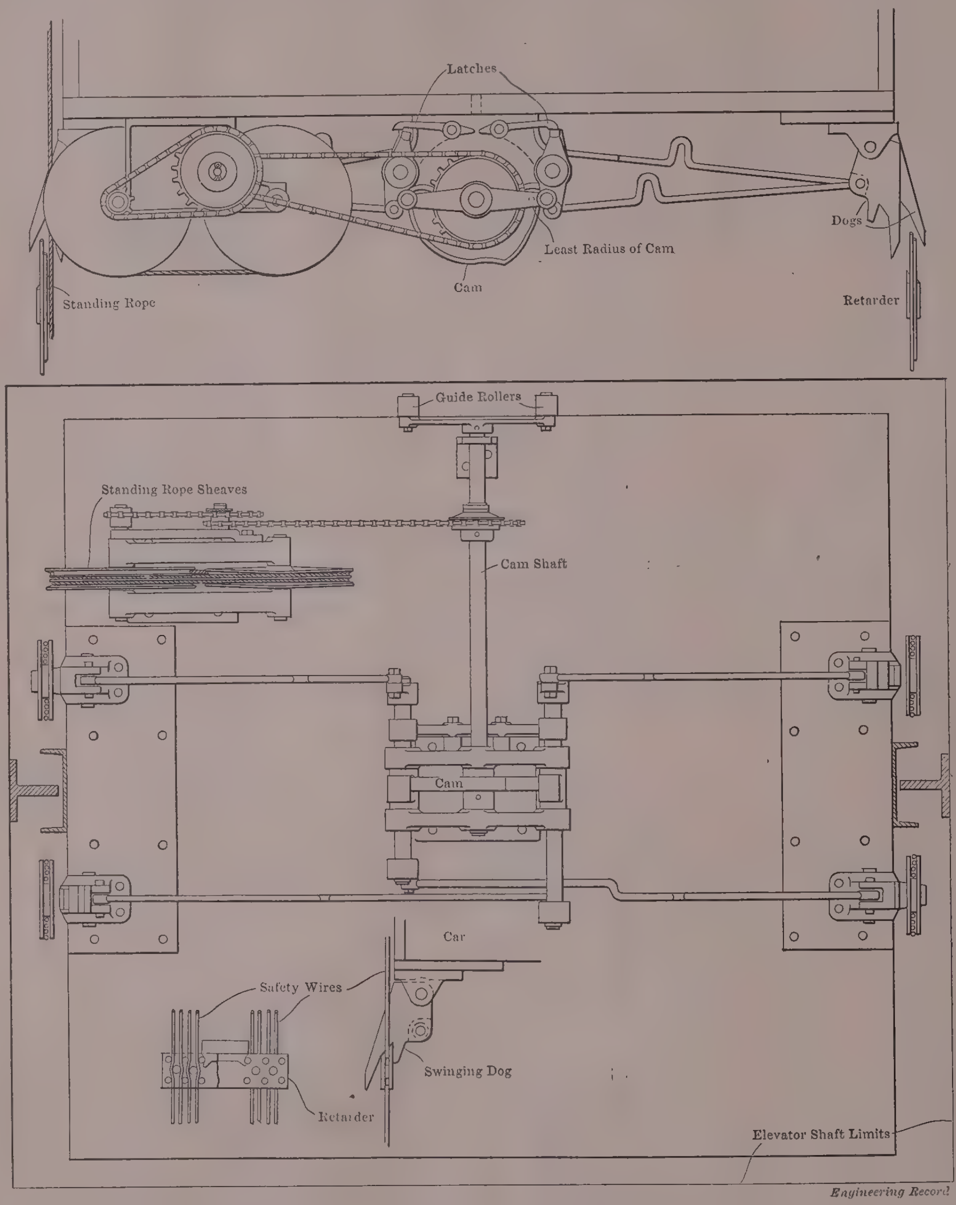
The retarders consist of double 10x3x¼-in. steel plates between which are mounted ½ and ⅝-in. steel pins so spaced as to kink the vertical safety wires when inserted between them. The smaller pins have shoulders which hold the plates about ¼ in. apart inside, so that the wires are held in the retarders only by the kinking effect upon them, and are not clamped tightly upon them for friction. Their operation is based upon the principle that if a rigid, straight wire is bent over three pins, resistance will be offered to the sliding of that wire through the pins in the proportion of the inverse cube of the distance between the pins. The relation of these distances between pins to the size of safty wire used is such as to give a sliding resistance of 400 lb. per wire, which is thus independent of friction, wear, contraction and expansion, and other disturbing influences. The resistance thus offered by a group of eight wires per retarder, is 3,200 lb., or for a pair of eight-wire groups which would be called into action if an elevator should drop, a total of 6,400 lb. As this resistance would take the form of a constant force of retardation and not that of impact, the predetermined loading of 400 lb. upon each wire of an ultimate tensile strength of 1,800 lb., gives a factor of safety of 4.5 for the safety wires. The retarders are put in place upon the safety wires by bringing the back plate, to which the ½-in. outside pins are rigidly fastened, up over the straight wires from the back and then bolting the front cover plate in place without the inner large pins which give the kink to the wires; these are then driven into place through the holes in the plates, using first a drift pin to spread the wires.

The catch dogs which are mounted upon the cars to engage with the retarders, consist of heavy vertically-swinging castings which are so formed that when swung outward they will act as rigid feet bearing beneath the car framing, a shoulder upon the dog coming in contact with the bottom frame so as to relieve the pivot of carrying the weight of the car in case of catching upon retarders. These hinged dogs are caused to reciprocate constantly when the car is in motion, by a special cam mechanism driven from the standing rope in the elevator shaft. The cam is so shaped as to cause the dogs to stand normally outward when between retarders but to swing in and out with a peculiar graduated motion when they pass the locking or catching points. The system is thus "a normal danger" system in that the dogs stand normally out in catching position, being pulled in only in passing retarders. The governor or automatic feature of the mechanism lies in a sharp raised portion upon the cam which precedes the point of least radius (marked by the circular hole in the web at one side) by which the dogs are given a peculiar quick outward thrust just before being drawn in to pass the retarders. This outward thust is so proportioned in relation to the weight of the hinged dogs and the speed of the car and cam shaft, that if the speed should exceed the normal from any cause whatsoever, the inertia given to the dogs would carry the cam levers out to a position where they would latch in the catching position and the dogs be caused to engage with the retarders. In this way the governing means, effective for dropping, are rendered delicate enough for over-speeds of from 100 to 200 ft. per minute above normal.

The catches or dogs on each car are arranged, in reference to the four groups of safety wires, in alternate pairs, those at diagonally opposite corners of the car being interconnected and the two pairs so driven as to operate alternately. The retarders upon the safety wires are similarly alternated upon the diagonally opposite groups in the elevator shafts. Thus when the car is passing a floor and one pair of dogs are drawn in so as to clear the retarders at that level, the other pair is projecting out to their extreme position for catching, ready for the next set below. The dogs are set so as, when drawn inward, to clear the retarders by ⅝ to ¾ in., but when extended to their extreme position, project from 1¾ to 2 in. beyond the tip of the retarder. The retarders are all tipped with an inclined chisel-pointed edge pointing inward to facilitate engaging with the dog.

The governing mechanism is mounted beneath the car, and has a standing-rope drive, the rope of which passes twice over two sheaves for a friction drive. The vertical outer sheave serves to drive the cam shaft through a double chain and sprocket gearing reduction, by means of which the proper rate of reciprocation of the dogs is obtained. In order to provide against the possible slippage of the standing rope upon these sheaves which would derange this motion of reciprocation, there is at the bottom of the elevator shaft a readjusting mechanism which will automatically reset the cam relative to the retarder passing points every time the car runs to the bottom of its shaft. The device consists of a pair of guide rollers mounted 10 in. apart upon two radial arms attached to the end of the cam shaft, which rollers come in contact with a curved guide at the bottom of the shaft. The shape of this guide is such, relative to the position of the rollers when the car is at the bottom of the shaft, as to slip the shaft around within the drive to its proper position, if it should be out. In order that the action of this mechanism shall not be required to slip the sheaves within the turns of the standing rope, the chain sprocket upon the cam shaft is mounted upon it with a friction attachment which permits of slippage at that point, although with sufficient difficulty so that slippage will not take place under ordinary driving conditions.

The design of this safety mechanism is to bring the car to rest, in case of failure of all supporting cables, with a uniform retardation; and for the best results in approaching a medium between the most rapid stop possible, which is dangerous to passengers, and the slowest stop which would necessitate greater spaces between retarders, the stopping forces have been designed to bring the cars to rest with approximately the same rate of retardation as the car accelerates in dropping until it catches upon the retarders. When the one pair of dogs catches upon a corresponding pair of retarders, the retarding force offered in stopping is that due to 16 wires or 6,400 lb. This is ordinarily sufficient to bring the car to rest before the second pair of dogs should engage with the other set of retarders, although, if for any reason this should not be the case, after the car had slipped down 12 ft. further, the second pair of dogs would pick up a second pair of retarders upon the remaining 16 wires and bring a total retarding force against further movement of the car of 12,800 lb. Thus under the most extreme conditions the car is bound to be caught and retained before it can drop to a distance greater than 24 ft. As the stresses brought upon the wires are definite predetermined quantities they can be kept within any desired limits and as here installed the factor of safety of 4.5 eliminates the possibility of breakage of the wires and in fact permits the strain of stopping a dropping car to be brought upon them an indefinite number of times without injury. In tests of this device, loaded cars have been dropped 20 and 30 times upon a single set of wires before it was found necessary to renew them.



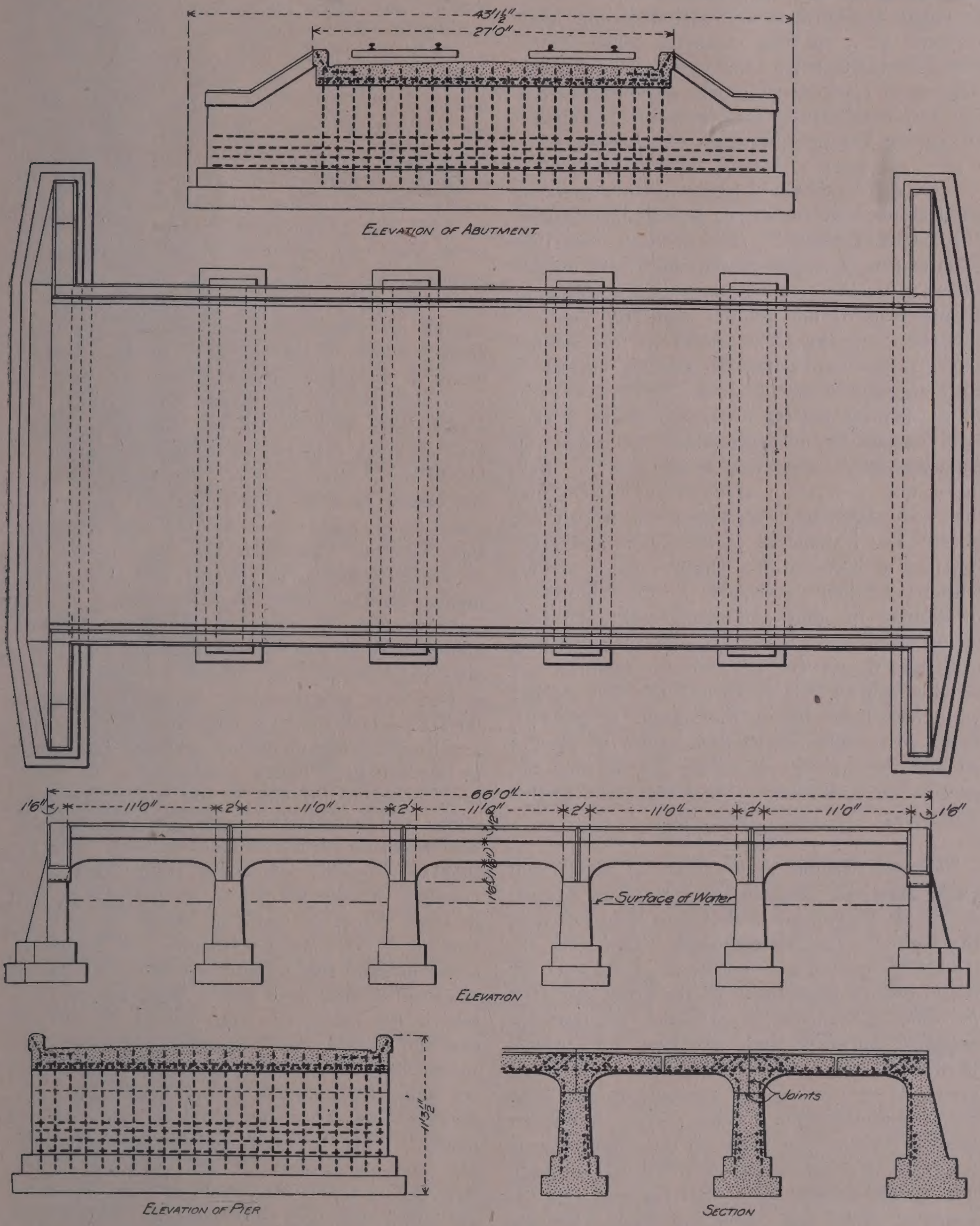
Details of the Governing Device Beneath the Elevator Car.

The same principle of retardation of cars is made use of in the Hotel Belmont installation for positive top limit stops, fitted to all of the high-rise shafts independent of the main elevator safety mechanism, and also to four sidewalk plunger elevator shafts. These limit stops consist of groups of short lengths of similar steel wire at the top of the shafts, upon which are mounted retarders, of similar construction to those upon the main safety systems, which are so set as to engage with projecting lugs upon the top of the car frames. They are adjusted a few inches above the upper limit of travel so that only in case of over-running upward will they be brought into action. In such a case, the car will be stopped with a force of 400 lb. per wire, or 4,800 lb. on each of the high-rise machines which have six wires per retarder; the slow-speed sidewalk machines, of only 1,300 lb. capacity, have four wires per retarder which will thus offer a total resistance of 3,200 lb.

A detail of the top limit stop for the high rise passenger machines, is shown in an accompanying drawing. The wires are bowed slightly over the retarders and as the thrust in stopping a car over-running at the top will be upward, the anchor points for these wires are taken below the retarder, at distances of about 15 ft. beneath the beams at the top of the shaft. The wires are fastened at the top by eye-bolts by which each individual wire may be tightened as required. The retarders are mounted on saddles spanning the elevator guide post, by which they are maintained in position to be engaged by the projecting lug or nose above the top of the elevator car framing. This nose is a heavy A-shaped forged strap set close to the guide rails. The limit stops on the sidewalk plunger machines are identical in principle with those of the passenger machines, the chief difference in construction being in the attachment of the noses, which are there mounted upon the lower edges of the car platforms.

While positive bottom limit stops of type just described are not used in the Hotel Belmont installation, due to lock of pit room, the main safety wires are carried down considerably below the lower limit of travel and the retarders are located so that if a car should travel below its lowest position as governed by the control-valve limit-stop, it would still have sufficient margin to engage with a retarder. With the cars in their lowest positions there is still left a distance of about 3 in. before the dogs engage with their retarders and moreover the retarders are fitted so as to have spaces of 18 in. in which to slide in case of a drop from the lowest floor level. In addition to this precaution for over-run at bottom, there is also installed what is termed an "emergency limit governor," which consists of a vertical cam or guide placed in shaft in the path of a small roller mounted on the cross-head of the car. This roller in passing the cam raises the catch dogs in the same manner as the governing cam under the car, but is entirely independent of the latter and is furthermore designed to latch up the dogs in the event of the machine automatics failing. The operation of this device is such that if a car approaches the bottom landing with proper slow down speed, the emergency governor has no effect, but if it does not slow down the dogs are latched up and engage a set of retarders placed several feet above the bottom car landing.

Tests recently made on the Cruickshank safety have indicated its capability of stopping a loaded car with uniform deceleration and with no injurious effect on the elevator or mechanism connected with it. An elevator car at the works of the company was recently loaded with 1,600 lb. of iron ballast, somewhat more than its maximum capacity, and allowed to drop by disconnecting it entirely from the supporting cables. The car fell 8 ft. 7 in. before catching on a retarder, after which it descended 9 ft. 4 in. further until its inertia was expended at the retarders and the car came to rest. These safeties and limit stops were installed on the hotel elevator equipment by the Security Elevator Safety Co., New York. The elevators were installed in the building by the Otis Elevator Co.



Standard Short Span Track Reinforced Concrete Bridge on Long Island R. R.

Short Span Concrete Bridges on the Long Island Railroad.

Timber trestle bridges on the Montauk division of the Long Island R. R. between Babylon and Oakdale are now being replaced by short span reinforced-concrete structures designed to carry the heaviest trains and locomotives at high speed. Among the practical considerations which led to the selection of the type adopted were, first, the facility for obtaining the materials, which could be promptly delivered and enabled the structures to be completed much sooner than would have been the case had it been necessary to wait for rolled structural materials in the present congested condition of the steel mills; second, the ability to make a solid floor, exempt from corrosion, not requiring painting, which would carry ballast and provide a solid roadbed, and thus reduce maintenance charges to a minimum.

The bridges are made without beams or girders, and the floor consists of a continuous wide platform covered with ballast and supported directly on the piers and abutments, which are spaced at comparatively short distances. The floor slabs are of uniform thickness except where the depth is increased at the ends by curves tangent to the lower surface and to the faces of the piers and abutments, and for the transverse crowning for drainage. The outer edges of the floor parallel to the axis of the bridge are provided with low face walls or curbs integral with the slabs which retain the stone ballast about 12 in. deep on which the track is laid.

The standard length of 11 ft. of clear span has been adopted for the bridges of this type, and, under the conditions imposed, calls for a minimum thickness of 18 in. in the floor slab, which, however, varies slightly on account of the pitch of the upper surface to longitudinal gutters providing for the drainage of the track and ballast. In two and three-track structures there are two of these gutters, one at each side of the bridge, and where there are four tracks there is a third gutter on the center line. The surface of the concrete slopes about 1 : 48 to the gutters and the gutters are pitched at about the same angle to drainage holes in the center of each span. The concrete is not waterproofed under the ballast, but the upper surface is troweled smooth so as to be sufficiently impervious to shed the water into the drains.

The bridge piers are 2 ft. wide over all and are battered 1.24 on their long faces. Their footings are made in two courses with 9-in. offsets 18 in. deep, and are carried down to hard bottom generally assumed to have a bearing value of 5,000 lb. per square foot.

The piers being spaced 13 ft. apart on centers afford bearing 1 ft. wide for each of the two floor slabs they support, with a butt joint on the center line of the pier. The depth of the floor slab is made 36 in. over the pier, thus providing an increased section for shearing stresses and showing a curved lower surface which bears some resemblance to an arch soffit, but is treated in design and construction as a simple flat slab. Each span is made as an independent slab with a horizontal joint on the top of the pier and a vertical transverse joint between it and the adjacent slab. All adjacent slabs are built separately and one of them is allowed to set before the other is constructed.

The work is designed for Cooper's E 50 loading. The concrete for the floor slabs is made 1:2:4 with Vulcanite Portland cement and ¾-in. broken stone mixed wet by hand. It is reinforced entirely with Ransome twisted steel bars, generally 1 in. square, which constitute slightly more than 1 per cent. of the cross-section of the slab and are proportioned in the main in accordance with Thacher's formula. The bars are arranged horizontally in two tiers near the lower surface of the slab. There is one set of longitudinal rods three-fourths of which have their ends bent upwards as indicated in the longitudinal section. A second set of ⅜-in. bars transverse to the first is laid on them and about 12 in. apart. Besides these bars short bent rods extend from the slabs into the curb walls, but all longitudinal bars are discontinuous over the pier joints.

The piers and abutments are made of 1:3:5 concrete with broken stone from 1½ to 2 in. in diameter. They are reinforced by vertical and horizontal 1-in. rods parallel with the long faces of the piers and 2 in. clear of them. Vertical rods are 14 in. apart and have their upper ends bent outwards to engage the curved extensions to the floor slabs. The horizontal rods are made in two lengths overlapping 28 in. at the center of the pier, and are carried up four courses above the footing.

Bridge 72 across Great River is a double-track structure 66 ft. long over all, and consists of five spans as indicated in the accompanying plan and elevations. It has a clear height of about 2½ ft. above the surface of the water, and the footings were carried down in open sheeted pits to a depth of about 6 ft. 2 in. below water level. This bridge contained in the floor slabs 135 cu. yd. of concrete made of 184 bbl. of cement, 59 cu. yd. of sand and 112 cu. yd. of stone. The piers and abutments contained 169 cu. yd. of concrete made of 200 bbl. of cement, 94 cu. yd. of sand, and 153 cu. yd. of stone.

Bridge 67 across Sutton's Creek is a three-track structure 40 ft. wide over all and 40 ft. long from end to end of the floor slab. It has three 11-ft. spans supported on the two abutments and on two intermediate piers, all corresponding with those of the Great River bridge. It has a clear height of about 4 ft. above water level and contains 137 cu. yd. of concrete in the floor slabs and 163 cu. yd. in piers and abutments.

Bridge 66 over Carlls River is a four-track structure which also has three 11-ft. spans and is 50 ft. 7½ in. wide over all. It differs from the spans previously described in that each abutment is continued beyond the side of the bridge in the same plane at one end, and at the opposite end is deflected at an angle so as to make an oblique wing wall. This bridge contains 152 cu. yd. of concrete in the floor slabs and 254 cu. yd. in the abutments. Besides these bridges others of similar construction are being built by the railroad company.

As the line between Babylon and Oakdale is now being changed from single to double track it is practicable to build the bridges in successive longitudinal halves and thus avoid obstruction to traffic or the difficulties of carrying traffic over the concrete bridges during their construction. Concrete is built in ordinary forms constructed of planed 2-in. square-edge boards which are not greased or lined and, on account of the short spans, can be satisfactorily braced from the exterior so that no through ties are required. The concrete is allowed to set about three days before the molds are stripped and traffic is not carried on it until it is about thirty days old. No settlement or deflection, and no cracks have been observed in the structures so far built, the joints being grouted afterwards so as to make a continuous surface. Where it is required to maintain traffic during construction, plans are made to cast the floor slab in a number of longitudinal sections or ribs weighing 3 or 4 tons each. After these have thoroughly set and have developed sufficient working strength, they will be picked up by a derrick car and successively set in position, on the piers without interrupting train service.

The bridges have been designed and constructed by the engineering department of the Long Island R. R. Co., and Mr. J. R. Savage, chief engineer, and Mr. J. B. French, bridge engineer.

Book Notes.

The lettering on drawings is one of the most important parts of a draftsman's work. No matter how well the ruling-pen work is done, the effect is marred seriously by any failure to letter the drawing neatly and clearly. In fact, so far as mere appearance is concerned, the lettering is far more important than the finish of the lines. Nevertheless few draftsmen seem to appreciate the necessity of learning to letter and figure properly. Neat, plain work is easily done after some experience and when the draftsman has subdued his desire for "ornamental" alphabets and "decorations" of a startling character. The fundamental idea is to letter so as to explain the drawing, not to decorate it. Some good suggestions can be secured in "A Chapter on Lettering." (Browning Press, Collinwood, O., 25 cents.)

A little book that will be useful to owners of small motor boats is Mr. E. J. Williams' "Gasoline Engine Ignition." It is probably true that boats of this class, particularly those used on salt water, cause the amateur more trouble owing to derangement of the ignition apparatus than on any other account. The author of this manual explains the construction of sparking devices in common use and points out the different ways in which they are put out of service. After a very brief explanation of magnetism, he takes up make-and-break and jump-spark ignition. Batteries and generators are next described, and then some good hints on testing for trouble are given. The installation of the engine and gasoline tank is discussed in a special chapter, and attention is called particularly to the importance of keeping the tank and piping tight and providing means for removing any gasoline that may leak from them. Too much stress cannot be laid on this subject, for practically the only danger with these boats lies in the leakage of gasoline. Some good notes on the horse-power of engines and on the methods of wiring the ignition apparatus are furnished. (Cincinnati, Gas Engine Publishing Co., cloth, 16mo, $1.)

The 1905 "Report of the Tests of Metals and Other Materials" made at the Watertown Arsenal is a book of 435 pages replete with information of the highest value to engineers. The work included 37 tests of gun specimens, 2,107 tests for the Ordnance Department of the army, 293 tests for other government departments, 265 tests for research purposes, and 933 tests for private parties. Tests on the endurance of different grades of steel to repeated alternate stresses have been continued from former years. A number of observations were made on the contraction in length of steel bars cooled in a bath of liquid air. The tensile strength of a steel bar was also determined, which was cooled and tested while immersed in a bath of liquid air. This sample showed a gain in strength of 35.5 per cent. over its strength at ordinary atmospheric temperature. While the steel displayed a contraction of area at the point of rupture not much below its normal value, there was no general elongation of the steel remote from the contraction in the immediate vicinity of the fracture. As is well known a series of excellent tests of large concrete columns, with and without reinforcement, is being conducted at the Arsenal, and this volume gives the results of the work along this line done last year. Although the investigations are not yet completed, no engineer engaged in the design of concrete structures can afford to neglect the study of the data already obtained. In a general way it may be said that the tests show the use of richer or leaner concretes influences the rigidity of the indurated material in a marked degree, as well as modifies the ultimate strength. Attention should also be called to the valuable data concerning the strength of brick piers reported in this volume, which continues similar information in previous reports. The book can be obtained on application to the Chief of Ordnance, U. S. Army, Washington.

Concrete Block Manufacture: Processes and Machines. By Harmon Howard Rice. New York, John Wiley & Sons; cloth, 8vo, 160 pp., $2.00.

This volume is the first which has appeared treating the infant industry of concrete block manufacture in a comprehensive and painstaking manner. The author takes up concrete, cement, aggregates, water, and other ingredients for blocks, and explains the methods of proportioning and mixing them. The shape of the blocks, the general processes used in their manufacture, plasticity, facing, ornamentation and curing all receive attention before the construction of block machines, the arrangement of plant and the work of the men engaged in the actual manufacturing processes are discussed. The voids in blocks are considered sufficiently important to have a chapter to themselves, and another important chapter relates to the quality of blocks. Testing blocks is a subject discussed from the point of view adopted by the people who framed the Philadelphia rules, which few engineers considered of much value owing to the poor grade of blocks they admit as safe. The uses of blocks, the causes of their failure, the cost of making them, block architecture and building construction, building regulations and the manufacture of lintels, columns, balustrades and other ornamental work are given some attention.

At the present stage of the block industry about every feature of the methods and materials employed are the subject of debate. Few makers have progressed far enough to recognize the true reason for all of their successes and failures; most of them have not advanced far enough to turn out good blocks continuously. It is natural, therefore, to find in this book statements which will be directly contrary to the opinions held by many successful block makers. The author very frankly warns the reader that he is dogmatic on disputed points, yet it would be well in some places to state the views he does not hold in a more detailed manner. It should be borne in mind that a good concrete block can be made in several ways and a detail of one process is not necessarily poor because it will not give the desired results in another process. One serious fault of the book is the fact that it does not state definitely the present uncertainty concerning the structural character of concrete blocks. Their strength and consequently their safe carrying capacity are still unknown. There have been a few isolated tests of them, like those on which the very unsatisfactory Philadelphia regulations are based, but the architect has no means of knowing how they rank with the various grades of brickwork and stone masonry in carrying loads. Until this information is obtained the people who employ the ordinary commercial concrete block for structures supporting heavy loads will be taking risks with the success of their work. Concrete blocks are such a valuable material that their misuse is to be deplored.

A Hydro-Electric Station will be constructed about 40 miles from Montreal by the Light, Heat & Power Co., of that city. There will be three 3,750-kw. units, each furnishing three-phase current of 4,000 volts and 7,200 alternations.

Letters to the Editor.

The Type of Buildings for San Francisco.

Sir: The great catastrophe at San Francisco and elsewhere throughout California has very naturally prompted the question whether or not it is possible in the future to prevent such great loss of life and property. We read during the past few days many answers to this inquiry.

Before detailed and scientific information regarding the facts of the earthquake is received it is somewhat premature to express final opinions; but enough evidence of a general nature has come to hand to warrant the conclusion that while it may not be within the bounds of human effort to entirely prevent, it is quite possible to minimize, the loss of life and property, should such another visitation occur, if proper precautions are taken in the rebuilding of San Francisco. We therefore take the liberty of expressing our views on the subject, believing that a thorough and free discussion among engineers will be of benefit to the community at large.

It is an engineering possibility to design a structure, such as a ship, for instance, that will withstand almost any kind of strain, and adapt itself to all manner of conditions. It is also an enginering possibility to design a steel-frame building so that it will stand a great deal of shock and inequality of settlement in the foundations, due to a distortion of the earth supporting it. The proper adaptation of such structures to the needs of those occupying them is a modifying condition, which, together with the architectural requirements, has to be considered in this problem. Broadly speaking, it is a question of applying sound engineering principles to the problem in hand.

Buildings for business and office purposes should not be high in the New York sense; it might be well to limit the height to 100 ft. There should be ample lot area, and the buildings should be cubical in shape, if possible, so that in the shape itself there would be an element of stability.

These buildings should be entirely of steel skeleton construction, in which the walls are supported at every floor. Columns should be as far apart as possible, and the connections and joints of columns, beams and girders should be so designed that while there would be enough stiffness to withstand wind pressure, an easy matter to take care of in buildings of the height and shape recommended above, there would be sufficient flexibility to allow the steel frame to adjust itself to unequal settlement of foundations within reasonable limits, without permanently injuring the steel skeleton.

Some have advocated the use of a steel frame as rigid as possible. This we believe to be a mistake, because such a frame could be very seriously injured, in fact, beyond the possibility of repair, if the inequality of the settlement in the foundations were sufficiently great.

Foundations should be carried down, if possible, to solid rock or hard pan, and spread over steel grillage, and all these foundations should be tied together with steel girders.

Floor construction should consist entirely of steel beams and girders, supported on steel columns, and the joist beams should not be spaced over 6 ft. apart.

Floors should be of reinforced cinder concrete, the reinforcing consisting of tie rods spaced about 6 in. apart and securely fastened to the beams, and a wire mesh should also be used in the floor slab, as an additional security to hold the concrete in position in case of fracture.

The walls should be as thin as possible, consistent with climatic conditions and the requirements of fire protection, and might better be made hollow with an air space. The best material for this purpose we believe to be reinforced concrete, with a framework of structural steel around all openings, and made practically in the same way as the floor construction described above, the important thing being that there should be plenty of steel reinforcement and that it should be securely fastened to the steel framework of the building. If brick or cement blocks are to be used, the walls should not be more than 12 in. thick, and should be well anchored to steel uprights spaced not more than 6 ft. apart, these uprights being attached to the steel frame of the building. It is needless to add that this work should be laid up only in Portland cement mortar, and that the workmanship should be of the highest order. Floors and walls built as described above might in case of an earthquake crack or warp, but it is difficult to imagine them collapsing.

Cornices and projections of masonry should not be allowed. If they are necessary from an architectural standpoint they should have a steel skeleton thoroughly well attached to the steel frame of the building, forming a support for the reinforced cement or copper covering.

The water and gas pipes and electric wires should have special ducts, and the practice of carrying these next the columns, and surrounded by their fireproof covering, cannot be too strongly condemned. There should be expansion joints in the water and gas pipes, to avoid breaking in case of settlement of building.

To fully protect a steel frame building against fire there is probably nothing better than concrete. All the columns, beams and girders in such a structure should be thoroughly encased in Portland cement concrete.

In the design of the new Lackawanna Terminal now being erected at Hoboken, N. J., from the plans of Mr. Kenneth M. Murchison, architect, the conditions to be considered were somewhat similar to those which might be expected in an earthquake, but to a less degree. Both unequal settlement of the foundations and shock had to be provided for, the building resting altogether on friction piles 80 to 90 feet long. It was so designed that unequal settlement will not injure the steel frame, and the walls were made of reinforced concrete as described above, for the same reason, and to withstand the shock due to a blow from a heavy ferryboat.

The use of monolithic reinforced concrete construction in place of the steel skeleton for the rebuilding of San Francisco, or for use in any earthquake district, does not appeal to us on account of its lack of flexibility. In the event of unequal settlement, numerous cracks would undoubtedly develop where columns and girders connect, and the repairing of such a building would be an exceedingly expensive and difficult matter.

Reinforced concrete construction has its uses; but in the present evolutionary stage of its development there is a strong tendency to employ it under improper conditions. Any condition which would crack a monolithic reinforced concrete building or cause the steel reinforcing rods to separate from the concrete should condemn its use for that particular case. For this reason it is not recommended for railroad bridges, nor does it appeal to one's judgment to use it for the frames of high buildings in localities subject to earthquakes.

Steel encased in cement is the best material known with which to construct the frames of high buildings, but to meet the complicated conditions such as the ideal building for San Francisco would require, the designs and details must be carefully worked out.

Yours truly,

Weiskopf & Stern,
Consulting Engineers.

New York, May 9.

Ventilation of Engine Rooms.

Sir:—Commenting on the editorial in your issue of May 5 on "Ventilation of Engine and Boiler Rooms" I would say that I succeeded in reducing the temperature of an engine room and making it fairly comfortable in the following manner: In the engine room in question was located a large fan which was used to exhaust the air from a large office on the floor just above. All the ducts were under the ceiling of the engine room. The discharge from the fan was connected into a vertical flue 20 stories high and 66x16-in. in section, located in an internal warm wall. I put in a damper at the junction of the horizontal discharge from the fan and the vertical flue, and cut openings in the discharge duct so that the fan discharged all the air withdrawn from the office above into the engine room. Then I connected the foot of the vertical duct by means of a by-pass with another hot part of the engine room, practically a separating room, thus using this warm vertical duct as an exhauster of the hot air, and also helping to draw in fresh air through a door to the outside. The fan and the vertical duct were thus used to improve the conditions of the engine room without additional cost.

Yours truly, A. M. Feldman.

New York, May 10.

The Education and Training of Engineers.

Sir:—One of the most important documents in connection with the engineering profession is a report adopted April 24 by the Council of the Institution of Civil Engineers, on the education and training of engineers. This pronouncement has been looked forward to with interest not only by those connected with the technical instruction of engineering students, but by all engineers who are concerned with the future of the profession. Though the conditions in America are somewhat different from those in the United Kingdom, to which the report more immediately refers, the conclusions to which it has come, weighted as they are with the signatures of the most eminent British engineers, will have great interest in the United States.

Though the subject has had the attention of the Institution in 1870, 1889 and 1897, the present and most important action was initiated, in 1903, by the Institution of Mechanical Engineers, London, who have been actuated by the intense, and in many cases successful, rivalry of foreign and American engineers, due, according to popular and often correct opinion, to their superior training, especially on the academic side; this view of the question is clearly seen throughout the report for the possibility of capable engineers being educated, as of old, solely by apprenticeship, which has produced many distinguished men in the past, is not alluded to, even for condemnation. This is, of course, as it should be, and is in thorough harmony with the previous action of the Council of the Institution in establishing examinations in 1897 as a means of entry into that body.

The Institution of Mechanical Engineers, which is a much younger society, addressed a letter on May 8, 1903, to the Council of the Institution of Civil Engineers, asking them to deal with the matter. Accordingly, at the latter's request in November, 1903, the undermentioned bodies appointed delegates who, with four leading members of the Council, were formed into a committee with Sir William White, the well known naval architect, and late chief constructor at the British Admiralty, as chairman. The following was the constitution of the committee: Sir William H. White, past president Inst. C.E., chairman; the president of the Institution of Civil Engineers, ex-officio; Sir John Wolfe Barry, past pres. Inst. C.E.; Sir Alexander B. W. Kennedy, vice-pres. Inst. C.E.; J. Hartly Wicksteed, M. Inst. C.E., representing the Inst. of Mech. Eng.; Alexander Gracie, M. Inst. C.E., representing the Inst. Naval Arch.; Sir Edward Carbutt, Bart., M. Inst. C.E., representing the Iron and Steel Institute; R. Kaye Gray, M. Inst. C.E., representing the Inst. of Elec. Engineers; Harry E. Jones, M. Inst. C.E., representing the Inst. of Gas Engineers; Prof. Archibald Barr, M. Inst. C. E., representing the Institution of Engineers and Shipbuilders in Scotland; Prof. Henry Louis, representing the Inst. of Mining Engineers; Prof. R. L. Weighton, representing the North-East Coast Institution of Engineers and Shipbuilders; J. H. T. Tudsbery, M. Inst. C.E., secretary; J. G. Henderson, Assoc. M. Inst. C.E., assistant secretary. Sir Edward Carbutt was replaced, on his death in October, 1905, by Mr. A. T. Tanner-Walker, M. Inst. C. E.

As most of these were busy professional men, and as they decided to form their conclusions, to a great extent, on answers received to queries sent out to about 800 equally busy engineers, professors, etc., it is remarkable that we have, in less than two and one-half years, a complete and fairly exhaustive result before us.

There is one feature in the composition of the committee which seems to call for comment, and that is the absence of special representation, of any university or engineering school as such, which certainly would have given a more representative character to the decisions arrived at. It is true that the names of three professors appear, one being of the University of Glasgow, but they were appointed as representatives of societies and institutions, and not of the academic side in the training of engineers.

The sections of inquiry were: 1, Preparatory education in secondary schools; 2, training in offices, workshops, factories, or on works; 3, training in universities and higher technical institutions; 4, post-graduate work.

As to No. 1 which was dealt with by a sub-committee, answers to queries were received from 80 per cent. of the 120 representatives of teachers in engineering colleges, head masters of secondary schools, and engineers not engaged in teaching. The sub-committee naturally say nothing about the very large percentage of boys who finish their school education before it is decided what calling they shall follow. This, in the full report, seems to be an omission, as the subsequent dealing with such students must be affected thereby; for example, as to the desirability, or otherwise, discussed later with reference to early training, of attendance at evening schools, during the subsequent workshop training.

To construct the perfect engineer, if there is such a thing, three conditions are essential. First, he must have conspicuous ability in one or more of the branches of intellectual ability which make for success in that particular calling. Secondly, the decision as to his avocation must be arrived at sufficiently early so that his studies should be in the right direction for the maximum amount of time. Thirdly, means must be at the command of those responsible for his training to provide the complete academic and practical instruction required. The great bulk of young men joining the profession have only a portion of these several means of ultimate success within their reach, but the committee seem to deal only with a counsel of perfection in these matters, and regard them, except as to the first condition of mental capability, as a matter of course. With respect to the latter, the committee sensibly say that they had in view an "average boy" of ordinary ability, geniuses being properly left to plan out their own career in their own way, but the committee might well have given some guidance in the numerous and also average cases, where training has not begun as early as desirable, and where circumstances are against complete training. It is well known, referring to the first point, that a boy's bent towards any particular profession, which is, after all, such an ingredient of success, is not always apparent, even to himself, before his schooldays are ended.

The recommendation as to school work may be summarized as follows: It is to embrace, beyond ordinary subjects (Greek being omitted), mathematical teaching, not as an intellectual exercise, but with the view to practical application; and in arithmetic, contracted methods and mental operations. Physics, chemistry and drawing are, of course emphasized, but not surveying, which is rightly deemed impracticable at this stage. A leaving examination is strongly insisted upon, and the time of finishing school is recommended to be at about 17 years of age.

With regard to the second part of the subject, professional training, a much smaller percentage of those, mostly engineers, to whom queries were sent, replied. Briefly, the results, in which the majority of opinions seem to have actuated the committee's final recommendations, are as follows, but it must be said that many of the questions were what lawyers would call leading ones, having more the effect, in many cases, of economizing the thinking efforts of those addressed, than of adding to the value of their replies: It is desirable that the student, after leaving school, should spend at least a year, if not two, in a mechanical engineering workshop before he enters college. As to the necessity for such a training, there will be no possible question, nowadays. Formerly many civil engineers, properly so-called, devoting themselves to the construction of railways, harbors, or water-works, and relying on three or four years' apprenticeship to a practising engineer, have been brilliant successes without this advantage, but the great advance of labor-saving machinery in later times, gives the man who has a practical knowledge of the construction and working of such appliances as pumps, hydraulic rams, testing machines, steam and gas engines, compressed air plants and machine tools, a great superiority over one who knows only about these things from text-books. The committee's word "desirable," in this recommendation, might well have been strengthened to "essential." In fact, the old distinction between a mechanical and a civil engineer is tending towards extinction.

That this introductory workshop course, as it is called, should precede the college period, however, is a matter on which many will have doubts, though a leading question on this point by the committee gets substantial support from those answering it. Undess the undesirable expedient of evening schools is adopted, there will be a serious break in studies, more especially on the mathematical side, and some retrogression in knowledge of this kind would be probably inevitable. It must be remembered that it is the average student that is in question, and a day's work in the shops, in which it is expressly laid down that he is to keep regular working hours, to be subject to discipline, and to receive wages, is not a good preliminary to evening study. The same objection applies to the alternative recommendation that the workshop course should intervene between the first session of college work, in which the instruction is usually general, and the remaining years, when the training is specialized to the branch selected by the student. In any case, he is to go back again to practical training in shop or on works, after the complete college course, this last training being specialized.

There are also many practical objections to this sandwich system, and it is therefore surprising that such a small number of answers oppose the committee's suggestions, and recommend the completion of the college course before the practical training has begun at all. The latter is a much simpler plan, and has produced so many successful men, that if there are any strong reasons in favor of the alternative one, it would have been more satisfactory if the committee had supplied them.

The report deals at length with the kind of training to be given at the college, but we have not space to refer to it, beyond noting that the recommendations are comprehensive and sensible. Among the latter is one that the degrees or diplomas should not be granted on the results of terminal or final examinations alone, and we might add that if the apitude of the student, during the previous workshop course, could be included as one of the criteria, the value of the distinction would be much increased.

After the college course is passed, the student proceeds to the practical training, in shop, factory, or works, in the specialty which he ultimately proposes to take up, this corresponding to the old apprenticeship time, and following, naturally, its methods. In some special cases, the committee contemplate a return again to college for special study, which is termed the "post-graduate" period or the fourth division of their subject.

Apart from the latter, the time to be given to the introductory workshop course together with the subsequent practical training is recommended to be from three to four years, and the college course to be also from three to four years, so that, assuming school left at 17, the completion of the training would bring our youth to 23 to 25 years before he could begin to look for a living.

London, May 2. M. Inst. C.E.

Railway Contract Litigation.

A contract complication of an unusual character was recently decided by the Iowa Supreme Court, 105 N. W. Rep. 509. A construction company, which was under agreement with a railroad for the building of its road, sublet the clearing of the right of way and grading to a subcontractor under a contract which provided that the work should conform to the plans and specifications of the chief engineer, who should decide questions which might arise between the parties relative to the work, and further provided for payment for the work on certificates of the chief engineer that the same had been completed. It became necessary, owing to the impossibility of completing the grading and laying of tracks within the time allowed the railroad for that purpose to entitle it to receive taxes voted in aid of its construction, to complete the laying of rails so as to enable a train to be run over the road within the prescribed time without regard to the finishing of the grading. The grading work, being done by the subcontractor, was accordingly suspended pursuant to order of the chief engineer, and the subcontractor did such work as was required of him by the chief engineer to enable the railroad to run its first train, and was given certificates of completion by the chief engineer. The court decides that under these conditions the subcontractor was entitled to recover the amount certified by the chief engineer to be due, although the work was not complete as originally contemplated by its contract.

The Steam Turbine is growing in favor in Southern cotton mills. The Francis Cotton Mills have ordered Westinghouse-Parsons equipment and the same type has been installed by the Pelzer Mfg. Co., the Henrietta Mills, the Gray Mfg. Co., the Modena Cotton Mills and the Lumberton Cotton Mills. The Southern mills have been the pioneers in introducing power novelties and the favor shown the turbine is in line with this policy.